PB85-147445

Removal of Heavy Metals Using Aluminum Salts for Phosphorus Removal

Rensselaer Polytechnic Inst., Troy, NY

Prepared for

Environmental Protection Agency, Cincinnati, OH

Jan 85

U.S. Department of Commerce
National Technical Information Service
NTIS

PB85-147445

EPA-600/2-85-003
January 1985

REMOVAL OF HEAVY METALS USING ALUMINUM SALTS FOR PHOSPHORUS REMOVAL

by

Donald B. Aulenbach, Nicholas L. Clesceri, Michael A. Meyer,
Chittibabu Vasudevan, Eileen Beckwith, Shrikant Joshi

Rensselaer Polytechnic Institute
Troy, New York 12181

Cooperative Agreement No. CR-809226

Project Officers

Sidney Hannah and Richard Dobbs
Wastewater Research Division
Water Engineering Research Laboratory
Cincinnati, Ohio 45268

WATER ENGINEERING RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-85-003	2.	3. RECIPIENT'S ACCESSION NO. PB85 147445 /AS
4. TITLE AND SUBTITLE Removal of Heavy Metals Using Aluminum Salts for Phosphorus Removal		5. REPORT DATE January 1985
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) D.B. Aulenbach, N.L. Clesceri, M.A. Meyer, C. Vasudevan, E. Beckwith, and S. Joshi		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Rensselaer Polytechnic Institute Troy, New York 12181		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO. CR-809226-01
12. SPONSORING AGENCY NAME AND ADDRESS Water Engineering Research Laboratory--Cin.,OH Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268		13. TYPE OF REPORT AND PERIOD COVERED Final 7-82 to 7-83
		14. SPONSORING AGENCY CODE EPA/600/14

15. SUPPLEMENTARY NOTES

Project Officer: Richard A. Dobbs, WERL, Cincinnati, (513) 684-7649

16. ABSTRACT

The use of aluminum salts to remove phosphorus is common practice It has been shown that aluminum salts are also capable of removing heavy metals, but the dosages were much greater than normally applied for phosphorus removal. This study investigates the removal of heavy metals in treatment plants which utilize aluminum salts for phosphorus removal. By choosing POTW's which practice phosphorus removal during the summer only and sampling before and after the discontinuation of aluminum salt addition, the effect of aluminum salt precipitation on heavy metal removal was determined.

The results show that copper, chromium, and to some extent, lead removal was enhanced by aluminum salt addition. For chromium, it appears that sodium aluminate addition improved removal but alum addition has no effect. The results confirm that phosphorus removal is enhanced greatly by the precipitant addition. Of the other metals evaluated, aluminum salt addition appeared to have no significant effect on cadmium and antimony removal, nor did it affect TOC removal.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Waste treatment Waste water Chemical removal	metals inorganic chemistry	07

18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 276
	20. SECURITY CLASS *(This page)*	22. PRICE

EPA Form 2220-1 (9-73)

DISCLAIMER

The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement number CR-809226 to Rensselaer Polytechnic Institute. It has been subject to the Agency's peer and administrative review, and it has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

FOREWORD

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water systems. Under a mandate of national environmental laws, the agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. The Clean Water Act, the Safe Drinking Water Act, and the Toxics Substances Control Act are three of the major congressional laws that provide the framework for restoring and maintaining the integrity of our Nation's water, for preserving and enhancing the water we drink, and for protecting the environment from toxic substances. These laws direct the EPA to perform research to define our environmental problems, measure the impacts, and search for solutions.

The Water Engineering Research Laboratory is that component of EPA's Research and Development program concerned with preventing, treating, and managing municipal and industrial wastewater discharges; establishing practices to control and remove contaminants from drinking water and to prevent its deterioration during storage and distribution; and assessing the nature and controllability of releases of toxic substances to the air, water, and land from manufacturing processes and subsequent product uses. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

Publicly owned treatment works (POTW's) have heavy metals in varying degrees in their influents. The removal of the metals is of concern because of their toxicity. This publication describes the results of an investigation of metals removal at three treatment plants that were using aluminum salts for control of phosphorus. In addition to the metals on the priority pollutant list, measurements of phosphorus, total organic carbon, biological oxygen demand, and suspended solids were made at different points in the treatment systems.

Francis T. Mayo, Director
Water Engineering Research Laboratory

ABSTRACT

Many publicly owned treatment works (POTW's) have heavy metals in varying degrees in their influents from either industrial or other sources. The removal of the metals, specifically the 13 on the priority pollutants list, is of concern because of the toxic nature of these metals.

Also of concern is the removal of phosphorus because it is a stimulant to biological growth in the receiving waters. The removal of phosphorus is required year round in POTW's in the Great Lakes Basin, but at other locations removal may be required only during the warmer months when aquatic growths would be more prolific.

The use of aluminum salts to remove phosphorus is common practice. It has been shown that aluminum salts are also capable of removing heavy metals, but the dosages were much greater than normally applied for phosphorus removal. This study investigates the removal of heavy metals in treatment plants which utilize aluminum salts for phosphorus removal. By choosing POTW's which practice phosphorus removal during the summer only and sampling before and after the discontinuation of aluminum salt addition, the effect of aluminum salt precipitation on heavy metal removal can be determined.

Three treatment plants were investigated, two of which utilize sodium aluminate and the other alum for phosphorus removal. They are all activated sludge plants treating primarily domestic wastes with some industrial input. One plant utilizes trickling filters prior to the activated sludge process. Another plant does not use primary sedimentation but has a final sand filter after secondary clarification. Composite samples were taken 30 days prior to and after the discontinuance of aluminum addition.

Samples were taken from the influent and effluent streams at all the plants. Additional samples were taken from the primary sedimentation effluent, where applicable , and from the sand filter effluent for the plant which utilizes no primary sedimentation. Weekly sludge and supernatant samples were also taken.

In addition to the 13 metals on the priority pollutants list plus aluminum, measurements were made of phosphorus, TOC, BOD and suspended solids. The phosphorus measurements were made to determine the extent of phosphorus removal with and without the precipitant addition. The TOC, BOD, and suspended solids values were measured to evaluate normal treatment process parameters and to determine the impact of aluminum salt addition on these parameters.

The results show that copper, chromium, and to some extent, lead removal was enhanced by aluminum salt addition. For chromium, it appears that sodium aluminate addition improved removal but alum addition has no effect. The results confirm that phosphorus removal is enhanced greatly by the precipitant addition. Of the other metals evaluated, aluminum salt addition appeared to have no significant effect on cadmium and antimony removal, nor did it affect TOC removal. The impact of alum or sodium aluminate addition on the remaining metals could not be determined. For thallium, beryllium, and nickel all influent concentrations were below detectable limits. For arsenic, mercury, selenium, silver, and zinc mostly all of the effluent samples were at or below the detection limit even without the addition of the aluminum salt, so the percent removal was dependent on the influent concentration only and the effect of precipitant addition is not known. Measurement of aluminum showed that overall removal of the influent concentration remained constant during and after the discontinuation of aluminum salt addition.

This report was submitted in fulfillment of Cooperative Agreement No. CR-809226-01 by Rensselaer Polytechnic Institute under the sponsorship of the U.S. Environmental Protection Agency. This report covers a period from July 7, 1982, to January 4, 1984, and work was completed as of January 4, 1984.

CONTENTS

ABSTRACT iv
LIST OF FIGURES ix
LIST OF TABLES x
ABBREVIATIONS AND TERMS xii
ACKNOWLEDGEMENT xiv

1. INTRODUCTION 1

2. CONCLUSIONS 2

3. RECOMMENDATIONS 3

4. LITERATURE REVIEW 4

5. SAMPLING TECHNIQUES AND ANALYTICAL METHODS 18
    STUDY SITE SELECTION AND DESCRIPTION 18
        Fitchburg 19
        Pittsfield 19
        Medfield 19
    FIELD SAMPLING PROGRAM 24
        Fitchburg 24
        Pittsfield 24
        Medfield 25
    PRELIMINARY TREATMENT OF SAMPLES FOR LABORATORY ANALYSIS 25
    LABORATORY ANALYSES 26
    QUALITY CONTROL 30
        Filter Apparatus 30
        Precision 32
        Accuracy of Analyses 32
        Standard Additions 32
        Summary 32

6. PRESENTATION AND DISCUSSION OF RESULTS 37
    RESULTS 38
        Silver 38
        Arsenic 38
        Cadmium 38
        Chromium 42
        Copper 42
        Mercury 45
        Lead 45

Antimony 45
Selenium 49
Zinc 49
Aluminum 49
Total Organic Carbon 53
Phosphorus 53
CORRELATION OF METALS REMOVAL TO TREATMENT PARAMETERS 53
Fitchburg 56
Pittsfield 56
Medfield 56
MASS BALANCES .58
DISCUSSION OF RESULTS 61

REFERENCES 69

APPENDIX A : Daily Concentrations 76

APPENDIX B : Descriptive Statistics of Concentrations and Removals 194

APPENDIX C : Results of t-tests 221

APPENDIX D : Field Data 226

APPENDIX E : Correlation Cceefficients 235

LIST OF FIGURES

Page

FIGURE 1 LOCATION OF TREATMENT PLANTS 20

FIGURE 2 FLOW CHART OF WASTEWATER TREATMENT PLANT AT FITCHBURG 21

FIGURE 3 FLOW CHART OF WASTEWATER TREATMENT PLANT AT PITTSFIELD .22

FIGURE 4 FLOW CHART OF WASTEWATER TREATMENT PLANT AT MEDFIELD 23

FIGURE 5 MEAN CONCENTRATION OF SILVER IN POTWs 39

FIGURE 6 MEAN CONCENTRATION OF ARSENIC IN POTWs 40

FIGURE 7 MEAN CONCENTRATION OF CADMIUM IN POTWs 41

FIGURE 8 MEAN CONCENTRATION OF CHROMIUM IN POTWs 43

FIGURE 9 MEAN CONCENTRATION OF COPPER IN POTWs 44

FIGURE 10 MEAN CONCENTRATION OF MERCURY IN POTWs 46

FIGURE 11 MEAN CONCENTRATION OF LEAD IN POTWs 47

FIGURE 12 MEAN CONCENTRATION OF ANTIMONY IN POTWs 48

FIGURE 13 MEAN CONCENTRATION OF SELENIUM IN POTWs 50

FIGURE 14 MEAN CONCENTRATION OF ZINC IN POTWs 51

FIGURE 15 MEAN CONCENTRATION OF ALUMINUM IN POTWs 52

FIGURE 16 MEAN CONCENTRATION OF ORGANIC CARBON IN POTWs .54

FIGURE 17 MEAN CONCENTRATION OF PHOSPHORUS IN POTWs . . .55

LIST OF TABLES

Page

TABLE 1 PROPOSED WATER QUALITY CRITERIA FOR PRIORITY POLLUTANT METALS 5

TABLE 2 TRACE METALS IN INFLUENT STREAMS FOR POTWS . . . 6

TABLE 3 RESIDENTIAL LOADING FACTORS FOR POTW 7

TABLE 4 PHASE DISTRIBUTION OF METALS IN RAW SEWAGE . . . 9

TABLE 5 REMOVAL OF HEAVY METALS IN POTW's 13

TABLE 6 RESIDUAL METAL CONCENTRATIONS 15

TABLE 7 REMOVAL OF METALS BY COAGULATION AND FILTRATION OF RAW WASTEWATER 15

TABLE 8 METAL REMOVAL BY ALUM COAGULATION OF WASTEWATER 16

TABLE 9 METHODOLOGY FOR METAL ANALYSES 28

TABLE 10 ANTIMONY DIGESTION COMPARISON TEST 29

TABLE 11 QUALITY CONTROL ON FILTER APPARATUS 31

TABLE 12 ANALYTICAL RESULTS OF INTERLAB QUALITY CONTROL : PRECISION .33

TABLE 13 ANALYTICAL RESULTS OF EPA QUALITY CONTROL SAMPLES 34

TABLE 14 METHOD OF STANDARD ADDITIONS 35

TABLE 15 SIGNIFICANT CORRELATION COEFFICIENTS 57

TABLE 16 CONCENTRATION OF METALS AND PHOSPHORUS IN SLUDGE SAMPLES 59

TABLE 17 CONCENTRATION OF METALS AND PHOSPHORUS IN SUPERNATANT SAMPLES 59

TABLE 18 RESULTS OF MASS BALANCES AT PITTSFIELD 60

TABLE 19 COMPARISON OF MEAN METALS CONCENTRATIONS IN THE FINAL DISCHARGE WITH DRINKING WATER STANDARDS 65

TABLE 20 COMPARISON OF MEAN METALS CONCENTRATIONS IN THE FINAL DISCHARGE WITH DRINKING WATER STANDARDS 66

TABLE 21 COMPARISON OF MEAN METALS CONCENTRATIONS IN THE FINAL DISCHARGE WITH DRINKING WATER STANDARDS 67

ABBREVIATIONS AND TERMS

A.TEMP = Air Temperature (°C)

BODF = Biological Oxygen Demand (5 day, 20°C) measured by treatment plant personnel

BODL = Biological Oxygen Demand (5 day, 20°C) measured in RPI laboratory

CL = Chlorine Residual (mg/L)

C.pH = pH of 24-hour composite sample

C.TEMP = Water temperature of composite sample (°C)

DO = Dissolved Oxygen (mg/L)

F = Filtered samples

FTP = Total Phosphorus measured by treatment plant personnel

G.pH = pH of grab sample

G.TEMP = Water temperature of grab sample (°C)

H_0 = Null Hypothesis in t-tests $(\mu_1=\mu_2)$

H_1 = Alternate Hypothesis in t-tests $(\mu_1=\mu_2)$

MLSS = Mixed Liquor Suspended Solids (mg/L)

ABBREVIATIONS AND TERMS (continued)

P = Total Phosphorus (mg/L)

POTW = Publicly Owned Treatment Works

SM = Settleable Matter

TOC = Total Organic Carbon

TSSF = Total Suspended Solids measured by treatment plant personnel

TSSL = Total Suspended Solids measured in RPI laboratory

TURB = Turbidity (NTU)

U = Unfiltered samples

μ_1 = mean fractional removal for cases with aluminum salt addition

μ_2 = mean fractional removal for cases without aluminum salt addition

α = significance level used in t-test

ν = number of degrees of freedom (in t-tests)

ACKNOWLEDGEMENT

The assistance of Kathryn Greaves and Ruth Yeomans in the laboratory is greatly appreciated. The authors would also like to extend their gratitude to the personnel of the wastewater treatment plants at Pittsfield, Fitchburg, and Medfield, Massachusetts for their assistance in collection of samples and for their cooperation in both sampling and analytical work.

Funds for this project were provided by the U.S. Environmental Protection Agency Project No. CR-809226.

SECTION 1

INTRODUCTION

Two of the many problems which are faced by operators of Publicly Owned Treatment Works (POTW's) are the presence of heavy metals and phosphorus. The heavy metals of concern as listed on the priority pollutants list are: silver, arsenic, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, thallium, and zinc. Contributions of heavy metals may be from industrial discharges, from food preparation and consumption, from household activities or from the original water supply. In general, large industries with high concentrations of heavy metals are required to pretreat their wastes prior to discharge. However, there are many small industries or industries with low heavy metal concentrations whose discharges are accepted by POTW's without pretreatment. Phosphorus is contributed by the water supply, by food and food products, by synthetic detergents, by water softeners, and by other substances used in the home.

Heavy metals are of concern primarily because of their toxicity to humans and other biological life. Phosphorus, on the other hand, is a stimulant to biological growth, especially to algae and aquatic weeds. Where phosphorus is the limiting nutrient, its removal from wastes can reduce biological productivity in the receiving waters.

Many POTW's practice phosphorus removal. In the Great Lakes Basin it is required to maintain effluent phosphorus concentrations at or below 1 mg P/L throughout the year. At other locations, the reduction of phosphorus in the discharge is required only during the summer months when aquatic plant growth is more prolific. The removal of phosphorus can be achieved through precipitation with aluminum, iron, or calcium salts. These salts have also been shown to remove heavy metals in the laboratory (Hannah,et al. ,1977) ,but at dosages greater than those required for phosphorus removal. Therefore it was considered possible that heavy metals may be removed gratuitously when aluminum salts are added for phosphorus removal.

This study was confined to three treatment plants which use alum or sodium aluminate for phosphorus removal during the summer months only. By measuring the heavy metal concentrations during the late summer when the aluminum salt is added and continuing measurement after the discontinuance of aluminum salt addition, any difference in heavy metals removal may be attributed to the discontinuance of the aluminum salt addition.

SECTION 2

CONCLUSIONS

The addition of alum or sodium aluminate at dosages which effectively remove phosphorus is beneficial in removing copper, chromium, and lead when present in wastewaters. The increased removal of copper is confirmed statistically for two of the plants - Pittsfield and Fitchburg. Chromium removal is enhanced by sodium aluminate addition, which is verified by the t-tests for Pittsfield, but alum does not affect chromium removal. Both types of aluminum salts appear to increase the removal of lead, but the large variance in the the data does not allow this to be confirmed by the t-tests.

Of the remaining metals analyzed, no difference in removal was observed with and without aluminum salt addition for cadmium or antimony, nor was there any difference in TOC removal. For silver, arsenic, selenium and zinc no comparison could be made since the majority of the effluent concentration values for these metals were at or below the detection limit even when no aluminum precipitant was added. Therefore, the removals were a function of the influent concentrations only and the effect of aluminum salt addition could not be determined. Mercury was effectively removed to below the detection limit by primary sedimentation, so no further removal was achieved during secondary treatment when the alum/aluminate was added. The remaining metals analyzed - nickel, beryllium, and thallium - were not present above the detection limits in the plant influents and, hence, no removal evaluation could be performed on them.

SECTION 3

RECOMMENDATIONS

Future work related to this study might include:

1.) Determination of the optimum point in a treatment process where the addition of a precipitant would be most beneficial in removing heavy metals and phosphorus.

2.) A more in-depth study on the best type of aluminum salt to use.

3.) A study of the effects of other chemical precipitants such as iron or calcium salts.

4.) A study of the solubility products of the metals. The concentrations of metals in the supernatant samples analyzed are generally constant for most metals, indicating a saturation value may have been reached.

SECTION 4

LITERATURE REVIEW

During 1971-1972, 629,000 pounds per year of metals were released into the environment in the state of Wisconsin, with nearly 50% of this released to the aquatic environment either directly or via treatment plant effluent (Konrad & Kleinert, 1974). Municipal wastewater treatment discharge was found to be a significant source of copper, cadmium, lead, and zinc in Chesapeake Bay (Bailey et al.,1975). Elevated levels of metals can affect the treatment process itself and the biota of receiving waters, as well as possibly degrading water sources used for drinking water supplies.

Proposed water quality criteria by the United States Environmental Protection Agency (EPA) include minimum concentrations of metals which may affect human health as well as fresh and salt water aquatic life (Convery et al., 1980). These criteria are listed in Table 1. Many states have adopted standards for priority pollutants, including heavy metals, in drinking water supplies. Therefore, the minimization of metals discharged into receiving waters is of importance.

The input of heavy metals into POTW's is variable. Geographic factors, the amount of industrial contribution, and the residential sources will affect the concentration of metals in POTW influents. A survey of 239 wastewater treatment facilities showed a wide range of metal concentrations (Table 2).

Residential sources can contribute greatly to the metals loading. Davis and Jacknow (1975) computed the loading factors of metals input into wastewater for three cities. These factors are shown in Table 3. Klein et al. (1974) presented data which indicated that residential sources contribute up to 38% of the metals input in New York City sewage.

Considerable input of mercury from residential sources has been attributed to the use of garbage grinders (Cox et al., 1975). A study of five public sewer systems in central Illinois showed mean concentrations of 1.3-1.8 ppb of mercury with daily values ranging from 0.1 to 7.9 ppb.

The amount of infiltration or inflow into domestic sewer systems can also affect the concentration of metals in the sewage. When combined sewers are used, street runoff can produce concentrations of some metals which can be 10 to 100 times those which are found in sanitary sewers alone (Pitt & Amy,1973).

The electroplating and photo engraving industries are the main industrial contributors of heavy metals to POTW's. They contribute from 7% of the zinc to 53% of the nickel found in New York City wastewater (Klein et al.,1974). Other industries

TABLE 1

PROPOSED WATER QUALITY CRITERIA FOR PRIORITY POLLUTANT METALS (Convery et al., 1980)

(Concentrations in ug/L)

METAL	FRESHWATER AQUATIC LIFE		SALT WATER AQUATIC LIFE		HUMAN HEALTH EFFECTS
	24-HR AVG.	CEILING	24-HR AVG.	CEILING	
Ag	0.009	1.9	0.26	0.58	10
As	120	1000	29	67	0.02
Be	exp(1.24ln(hard.)-6.65)	exp(1.24ln(hard.)-1.46)	--	--	0.087
Cd	exp(0.87ln(hard.)-4.38)	exp(1.30ln(hard.)-3.92)	1.0	16	10
Cr	--	--	--	--	50
Cu	exp(0.65ln(hard.)-1.03)	exp(0.88ln(hard.)-1.03)	0.79	18	1000
Hg	--	--	--	--	--
Ni	exp(1.02ln(hard.)-1.02)	exp(0.47ln(hard.)+4.19)	--	--	133
Pb	exp(1.50ln(hard.)-3.37)	exp(1.50ln(hard.)-1.39)	--	--	50
Sb	120	1000	--	--	145
Se	9.7	2.2	4.4	10	10
Tl	--	--	--	--	4
Zn	exp(0.67ln(hard.)+0.67)	exp(0.64ln(hard.)+2.46)	--	--	5000

TABLE 2

TRACE METALS IN INFLUENT STREAMS FOR POTW (Minear et al, 1981)

METAL	NO. OF PLANTS MEASURING METAL	FREQUENCY OF DETECTION	CONCENTRATION (ug/L) MINIMUM	MAXIMUM
Ag	83	77.5	1.5	900
As	71	58.5	0.3	1900
Be	9	18.7	1.0	90
Cd	212	58.9	0.2	2140
Cr	232	86.5	0.8	83300
Cu	238	92.5	0.1	36500
Hg	124	80.2	0.1	3000
Ni	203	79.2	2.0	111400
Pb	205	80.9	1.0	11600
Sb	11	6.5	0.3	2100
Se	41	57.3	2.0	10000
Zn	234	98.1	0.1	28700

TABLE 3

RESIDENTIAL LOADING FACTORS FOR HEAVY METALS

(Loading in lbs/day/1000 persons)

METAL	NEW YORK	PITTSBURGH	MUNCIE
Cd	0.016	0.011	0.006
Cr	0.080	0.018	0.007
Cu	0.180	0.100	0.100
Ni	0.080	0.012	0.020
Pb	--	0.062	0.100
Zn	0.210	0.167	0.210

which contribute may include: automobile, fertilizer, flat glass, cement, lime, gypsum, asbestos, inorganic chemicals manufacture, tanning, metal finishing, pulp and paper, steel, and textile industries (Handbook for Monitoring Industrial Wastewater, 1973).

Once released into the waste stream, each heavy metal may undergo a complex series of reactions involving complexation, phase transformation, or possibly oxidation-reduction. Even in the case of river systems, it has been reported that most of the iron, nickel, cobalt, chromium, copper, and manganese can be found in nonsoluble phases including solids-adsorbed fractions, as well as crystalline, coated, and biological components (Gibbs, 1973). It has also been found that in an aquatic system copper is associated primarily with colloidal organic matter, lead is in both organic and inorganic forms, cadmium is present as a free ion, and zinc can be found in ionic or colloidal forms (Allen et al., 1980). For wastewater, it has been found that metals may be discharged in the suspended as well as the soluble fraction, such as the case in the effluents of lead milling and mining operations (Jennett and Wixon, 1975).

The phase distribution of spiked additions of metals in raw sewage was studied by Patterson et al. (1975). The results showed that considerable amounts of trace metals, with the exception of nickel, could be present in a nonsoluble form (Table 4). The size distribution of the metallic solids is important when considering the removal of trace metals in a treatment process. In the work of Patterson et al. (1975), it was found that approximately half of the nonsoluble metals were also settleable under conditions similar to those found during primary sedimentation.

The concentration of the free, soluble, uncomplexed metal can be predicted when the solubility of the limiting solid phase is known. For example, Sylva (1976) suggests that the copper compound, malachite, is the limiting phase under many environmental conditions. Once the limiting ionic solubility is known, the total solubility can be predicted from metal-ligand complexation constants. Inorganic ligands such as hydroxide, chloride, carbonate, ammonia, and cyanide can increase solubility in cases pertinent to wastewater treatment. Theoretical calculations with Hg(II), Cd(II), Zn(II) and Pb(II) and the significance of chloride and hydroxide have been published (Hahe and Kroontje,1973).

Unfortunately, when the medium is as complex as wastewater, not all ligands which affect solubility can be identified. Chau (1973) noted that effluent from a sewage treatment plant contained 1.8-2.5 micromoles/Liter of copper complexing capacity of indeterminate composition. Despite these difficulties, several groups of workers (Patterson et al., 1975; Cheng et al., 1973; Haas, 1974) have determined stability constants for compounds present in a variety of wastewaters. Gardiner (1974) validated this type of model in the case of cadmium, which was found experimentally as the free divalent cation, accounting for 32-38% of the total soluble metals in wastewater effluents. This was in accordance with

TABLE 4

PHASE DISTRIBUTION OF METALS IN RAW SEWAGE

(Patterson et al, 1975)

METAL	SOLUBLE (%)	NON-SOLUBLE (%)
Cd	33	67
Cu	32	68
Ni	92	8
Pb	1.3	98.7
Zn	10	90

the theoretical calculations after consideration of the hydroxyl, carbonate, chloride, sulfate, and organic complexes.

The use of solubility calculations for prediction of metal dynamics in wastewater treatment can aid in the prediction of heavy metals removals. For chemical treatment, Lewandowski and Abd-El-Bary (1980) have found solubilities of metal compounds formed with carbonates, sulfides, and hydroxides. In the case of biological treatment, Cheng et al. (1973) have proposed the use of semi-empirical soluble and sludge phase stability constants for removal predictions.

Early studies by Jenkins et al. (1965) showed that more than 50% of the total copper, zinc, chromium, and nickel added to a sewage sample was taken up into the solid phase. They also reported that this uptake was rapid. However, these tests were done at metal concentrations of 10 mg/L or more, which exceeds the concentrations which would normally be found in a wastewater stream.

Two studies of wastewater treatment plant effluents (Bruland et al., 1974; Chen et al., 1974) reported that the particulate fraction of the discharge can contain up to 0.23-0.30% by weight of mercury, manganese, cadmium, lead, nickel, copper, chromium, zinc, silver, cobalt, and iron. Chen et al. (1974) also found that 60-85% of the cadmium, chromium, copper, mercury, zinc, and iron present in the primary effluent was greater than 0.2 microns in size. Conversely, for nickel, lead, and manganese, less than 20% was greater than 0.2 microns. In the Los Angeles County Sanitary District Joint Water Pollution Control Project, the distribution of settling velocities for cadmium, zinc, iron, chromium, and copper in the primary effluent was indistinguishable from the overall suspended solids distribution (Morel et al., 1975).

Considerable work has been done on the removal of heavy metals during the activated sludge process. Removal during biological treatment is possible since microorganisms are able to accumulate significant concentrations of heavy metals from dilute solutions (Bowen,1966).

The uptake of metals by activated sludge flocs appears to be a rapid process (Cheng et al., 1973). Lewandowski and Abd-El-Bary(1980) report that the initial uptake is by surface adsorption which is followed by metabolic incorporation of the metals by the microorganisms. Uptake of mercury and cadmium by activated sludge has been shown to follow a Freundlich isotherm (Neufeld and Hermann, 1973), while several other metals can be described by the Langmuir isotherm (Neufeld et al., 1977).

The removal of a metal by activated sludge is dependent on the metal under consideration. The efficiency of removal by sludge flocs correlates with the apparent sludge-metal complexation constants. Cheng et al. (1973) found that the efficiency of removal decreased in the order: lead, copper, cadmium, nickel. Neufeld et al. (1977) also reported a similar order: lead, cadmium, mercury, chromium(III), chromium(VI), zinc, nickel. Two studies have shown that pH is an important factor influencing metal adsorption on inorganic and organic surfaces. Cheng et al. (1973) report an increase in metal uptake with increasing pH. Nelson et al. (1981) state that there is an optimum pH for each metal for maximizing adsorption.

A survey of three treatment plants by Convery et al. (1980) showed a wide range of metal removal rates by activated sludge systems. For lead, nickel, cadmium, and copper, no removal was achieved for at least one plant while up to 55-97% removal was achieved for the other plants surveyed. Chromium and zinc were removed efficiently from all three plants with removals from 69 to 91 percent.

The Kokomo, Indiana Sewage System features an activated sludge system followed by a multi-media filter. The removal efficiency of this system for copper, chromium, zinc, nickel, and lead was investigated by Yost et al. (1981). Through the activated sludge stage 62-90% removal was achieved for all metals except nickel, which only achieved 14% removal. Overall, the system removed 80-98% of the influent metals with the exception of nickel, for which a 30% removal was achieved.

The proportion of dissolved to total metal increases for most metals as they pass through a conventional activated sludge system (Oliver & Cosgrove, 1974). A study of the Hyperion wastewater treatment plant, which achieves 90-95% suspended solids removal, resulted in differential removal of several groups of metals (Chen et al., 1974). Total metal removals of 70-85% were achieved for chromium, copper, iron, and mercury with only 40-75% of the soluble fraction being removed. For cadmium, nickel, lead, zinc, and manganese, reductions of 30-60% of the total metal concentrations and less than 40% of the soluble fractions were achieved. For the cases of cadmium and zinc, the concentrations of the soluble metal increased across the treatment plant.

The characteristics of the activated sludge process may influence metals removal. Esmond and Petrasek (1974) reported that the degree of nitrification was inversely correlated to the percent removal of trace metals. A similar relationship with the amount of COD present and the metals removal was found (Sterritt et al., 1981). However, at least two groups (Stroveland et al., 1979; Nilsson, 1971) have shown that the presence of phosphates had no effect on metals removal. The degree of suspended solids removal showed a positive correlation with the degree of metal removal (Brown et al., 1973) as did the influent metal concentration (Brown et al., 1973; Zemansky, 1974). Operating characteristics may also affect removal of metals. Zemansky (1974) reported that the metal removal decreased with increasing hydraulic loading rate. There also seemed to be an optimum sludge age at which to maximize metal removal (Sterritt & Lester, 1981; Rossin et al., 1982)

Mass balances by Barth et al. (1965) traced metal transport through several wastewater treatment plants. In many cases, the recycle stream of anaerobic digester supernatant was a significant source of metals to the primary clarifier. Similarly, Brown et al. (1973) reported maximum removals of many metals when there was no anaerobic digestion or supernatant recycle. Patterson et al. (1975) noted that most of the removal of cadmium, copper, lead, and zinc in a full scale installation could be attributed to waste activated sludge; for nickel, no observed removal was noted in the secondary treatment step. A study by Sverdrup and Parcel (1977) summarized the performance of 22 POTW's, which were meeting the standards for secondary treatment, for removing heavy metals. These results, in addition to results from other investigations, are summarized in Table 5.

In addition to removal during primary and secondary treatment, heavy metals may be removed by a variety of methods. These include reverse osmosis, electrode deposition, ion exchange, cementation, and activated carbon (Sverdrup and Parcel, 1977). The ability of alum, iron, or lime coagulation, activated carbon, and ion exchange to remove a variety of metals during potable water treatment has been reviewed by the National Academy of Science, (1977).

Sand was found to have no adsorptive capacity for a variety of metals in a pure system (Netzer & Wilkinson, 1974). However, when treated wastewater was percolated through soil, successful reduction of iron, manganese, nickel, copper, zinc, lead, and cadmium was observed (Lehman and Wilson, 1971). Mercury can be removed in a clean activated carbon system. Removal is enhanced by the addition of a chelating agent (resulting in a possible adsorption of the metal ligand complex) and by pretreatment of the carbon with carbon disulfide (Humenick & Schnoor, 1974).

Precipitation of heavy metals using multivalent ions such as calcium, aluminum, or iron is an effective means of removal. There are few POTW's, however, which employ chemical coagulation primarily as a means of metal removal, although lime precipitation is common in many industrial situations. The use of chemical precipitants in POTW's is primarily for turbidity or phosphorus reduction (David _et al._, 1976; McGinnes & Harriger, 1973; Ockershausen, 1980). The mechanism for removal of metals by coagulation-flocculation may be by reduction of solubility, removal of suspended solids, ion-exchange with floc particles, co-precipitation, or adsorption (Hannah _et al._, 1977).

Coagulants are able to reduce metal concentrations, in some cases, to levels below what would be expected by considering solubility products. Kinniburgh _et al._ 1977) reported that cadmium and zinc were able to adsorb to hydrous aluminum and iron oxide surfaces. Leckie _et al._ (1978) observed that the adsorption of silver, mercury, cadmium, copper, zinc, and lead to aluminum and iron oxides was rapid and addition of organic metal complexing agents could increase or decrease metal removal, depending on the nature of the metal-ligand interaction.

Over 60% removal of barium, cadmium, cobalt, iron, manganese, silver, and zinc may be achieved using lime precipitation for water treatment (National Academy of Science, 1977). As opposed to wastewater, metals in a water system would be expected to be in soluble form and less associated with soluble organics. Iron coagulation produced similar results for the removal of cadmium, iron, and manganese while alum did the same for copper and lead (Legendre & Runnels,

TABLE 5

REMOVAL OF HEAVY METALS IN POTW

(All removals in %)

TYPE OF SYSTEM	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Zn	REFERENCE
Prim. w/o digestion			25.0	36.5	69.5	53.8		59.0		67.4	Brown et al,1973
Prim. with digestion			0.0	26.0	58.5	25.0		28.0		55.5	
Prim. with digestion			13.0	16.9	27.9	12.5		33.3		43.3	
Prim. with digestion			20.0	28.9	12.4	36.0		28.3		21.5	
Trickling Filter			28.6	37.9	65.4	46.7		55.8		50.8	
Activated Sludge			11.1	78.0	10.6	16.7		42.5		48.4	
Activated Sludge	94.0	63.0	0.0	79.0	97.0	82.0	24.0	0.0	0.0	60.0	Convery et al,1980
Activated Sludge	77.0	19.0	<97.0	89.0	0.0	24.0	55.0	86.0	34.0	91.0	
Activated Sludge	26.0	50.0	--	71.0	0.0	93.0	0.0	60.0	--	71.0	
Activated Sludge and Gravity Filter			62.4	90.2	65.8		14.1	89.6		76.4	Yost et al,1981
			80.9	97.9	85.0		29.1	74.9		88.7	
Activated Sludge			66.7	67.4	55.9		10.3	81.5		64.7	Jacknow & Davis,1975
Activated Sludge				80.6	72.6		17.9	76.3		73.1	
Activated Sludge			80.0	79.0	73.0	>85.0	16.0	93.0			Oliver&Cos-grove,1974
Survey of 22 POTW			45.0	76.0	82.0	41.0	33.0	65.0			Sverdrup & Parcel,1977

1975).

Nilsson (1970) performed laboratory studies on the removal of metals from primary and secondary effluents by coagulation with lime and alum. Lime precipitation was able to reduce lead, copper, cadmium, arsenic, chromium, and zinc concentrations significantly. Pilot plant studies using tertiary treatment of activated sludge effluent were conducted by Esmond and Petrasek (1974). The treatment included high lime plus ferric chloride coagulation followed by filtration and activated carbon adsorption. The highest removal during coagulation was achieved for chromium, the lowest for cadmium. Overall removals were reported for chromium, manganese, zinc, nickel, copper, selenium, mercury, iron, arsenic, lead, and cadmium. Porcella and McGauhey (1976) attribute low metals concentration in the effluent of the tertiary treatment plant in Lake Tahoe to lime precipitation used for phosphorus removal.

The results of a pilot plant study on the removal of metals from raw wastewater by coagulation are shown in Table 6. A similar study by Hannah et al. (1977) reported metals removal using lime, ferric chloride, or alum coagulation followed by filtration (Table 7).

The removal of metals by alum coagulation has received limited attention in the literature. The work of Nilsson (1970) showed that lead, copper, chromium, and arsenic could be reduced significantly by alum precipitation. Cadmium and zinc were also removed to a lesser extent, while nickel was not influenced by the addition of alum at all. The metals concentrations used, however, were elevated (3-60 mg/L) so that extrapolation to full scale facilities is difficult.

Lindstedt et al. (1974) and Convery et al. (1980) reported metal removals from alum clarification of secondary effluent. Pilot plant removals using alum in physical-chemical treatment of raw wastewater were reported by Hannah et al. (1977). Data from these groups are summarized in Table 8.

A preliminary study of metals removal at the Pittsfield POTW was conducted by Keough in 1978. Due to financial restrictions, studies were limited to grab samples of the effluent, activated sludge effluent, and final effluent after alum addition and secondary sedimentation. Analyses were conducted on only filtered samples and during the time of alum addition. Cadmium was seldom detected above its detection limit. Iron to a large degree and copper and manganese to a lesser degree actually showed increases in concentration between the influent and the primary sedimentation effluent. This was attributed to sludge supernatant return which enters the system between these two sampling points. Zinc increased in passing through the trickling filter, whereas iron, copper, and manganese were reduced in this unit process. The activated sludge process significantly removed zinc, copper, and manganese. Addition of alum with sedimentation greatly increased iron removal and somewhat increased manganese removal. There was no change in the zinc concentration, and the copper removal decreased due to the alum addition.

TABLE 6

RESIDUAL METAL CONCENTRATIONS (Maruyama et al,1975)

Effluent concentrations (in ug/L)

METAL	SYSTEM		
	IRON	LOW LIME	HIGH LIME
As	58	915	770
Ba	271	25	942
Cd	50	44	14
Cr	21	87	76
Cu	155	169	352
Hg	--	--	54
Mn	3820	257	37
Ni	37	38	12
Pb	30	29	19
Zn	192	561	584

TABLE 7

REMOVAL OF METALS BY COAGULATION AND FILTRATION OF RAW WASTEWATER

(Hannah _et al_., 1977)

OBS. REMOVAL	METALS REMOVED		
	BY LIME	BY FeCl3	BY ALUM
<50%	Mo	Co and Tl	Mo,Tl,Zn, Mn and Ni
50-90%	Sb and Se (60ppb)	Mo,Sb and Se	Co,Cd,Sb and Se
90-95%	Hg,Sn,Tl and V	Ti	Sn and Ba
95-100%	Ag,Be,Bi,Co, Se(500ppb) and Ti	Ag,Be,Bi,Hg, Sn and V	Ag,Be,Bi,Hg, Ti,V,Cr,Cu and Pb

TABLE 8

METAL REMOVAL BY ALUM COAGULATION OF WASTEWATER

METAL	LINDSTEDT ET AL (1974)	CONVERY ET AL (1980)	HANNAH ET AL (1977)
Iron	43.2	--	--
Manganese	31.3	--	30
Chromium	53.8	--	Cr(VI) :64 Cr(III):97.6
Lead	18.2	87.9	--
Zinc	Neg.	--	1
Cadmium	19.2	95.6	45
Molybdenum	13.8	--	Neg.
Silver	--	--	96.9
Beryllium	--	--	98.1
Bismuth	--	--	95.5
Cobalt	--	--	49
Mercury	--	94.2	94
Antimony	--	--	62
Selenium	--	--	48
Tin	--	--	95.3
Titanium	--	--	95.8
Thallium	--	--	31
Vanadium	--	--	94
Nickel	--	--	25
Barium	--	--	79
Copper	--	87.4	67

It is in these situations, where alum is applied for phosphorus and/or suspended solids reduction, that the gratuitous removal of heavy metals is of greatest interest. Therefore, this study is to investigate the removal of heavy metals in POTW's using alum or sodium aluminate as an additive intended for the removal of phosphorus.

SECTION 5

SAMPLING TECHNIQUES AND ANALYTICAL METHODS

Previous studies have shown that aluminum salts (alum and sodium aluminate) were effective in reducing heavy metals in wastewater in pilot plant studies. However, these studies were conducted with the specific objective of removing heavy metals. Effective dosages were found to average about 220 mg/L (Hannah et al., 1977). Treatment plants using aluminum salt for phosphorus removal may not add sufficient aluminum to remove both the phosphorus and the heavy metals. Concentrations of 40 to 150 mg/L are usually used for phosphorus removal (McGinness & Harriger, 1973; Lindstedt et al., 1974). Also, different treatment processes may achieve different degree of metals removal.

In order to determine whether or not aluminum in concentrations required for phosphorus removal were effective in removing metals under actual conditions, treatment plants capable of discontinuing phosphorus removal had to be identified. Since this project was somewhat limited, criteria for selection of treatment plants had to be established. Sampling techniques had to be restricted to available equipment and instrumentation. Methods were therefore adapted to the specific conditions encountered in this study.

STUDY SITE SELECTION AND DESCRIPTION

The criteria used to select the wastewater treatment plants for this study were:

a.) the presence of some industrial waste or other source of heavy metals,

b.) the seasonal use of alum or sodium aluminate for phosphorus removal in which the coagulant would be discontinued during the study period,

c.) nearness to the RPI campus to minimize the lag time between sample collection and processing,

d.) the willingness of plant personnel to participate actively in the collection of samples and the accumulation of plant data,

e.) the incorporation of activated sludge in the treatment process.

To a lesser extent, plants employing different degrees or types of treatment (i.e., coagulation, trickling filter, sand filter), different points of alum addition, different amounts of industrial waste in the combined sewage, and different design capacities were also considered. Since all these combinations cannot be studied in one project, a cross section of treatment plants having a variety of parameters was chosen.

Three POTW's which practice phosphorus removal using alum or sodium aluminate during the summer months only located in Massachusetts (as shown in Figure 1) were used for the study. There was no special effort to identify treatment plants which had unusual industrial discharges, although each plant had some normal industrial discharges.

Fitchburg

The average flow at the Fitchburg POTW was 34,000 cubic meters/day (9mgd). The process in use during the sampling period is shown schematically in Figure 2. The basic process includes primary sedimentation, mechanical aeration activated sludge, secondary sedimentation, and chlorination prior to discharge into the Nashua River. Alum in the range of 8mg/L is added prior to the activated sludge aeration tank. Sludge from primary sedimentation is thickened in a gravity thickener while the secondary clarifier sludge is thickened in a floatation thickener. Supernatant from both thickeners is recycled to the influent of the aeration tank. The sludge from the thickeners is vacuum filtered and then incinerated. The filtrate and the scrubber water from the incinerator are recycled back to the head of the treatment process.

Pittsfield

The flow at the Pittsfield POTW was approximately 30,000 cubic meters per day (8 mgd). The treatment process in use at the time of sampling involved primary sedimentation, trickling filter, mechanical aeration activated sludge (without the use of the intermediate settling tanks, as shown in Figure 3), secondary sedimentation, chlorination, and discharge to the Housatonic River. Sodium aluminate, used to precipitate phosphorus, is added in doses of 27-33 mg/L to the combined stream between the activated sludge units and the secondary settling tank. The combined sludges are digested anaerobically to produce methane for power generation at the treatment plant. The sludge supernatant and waste sludge, when required, are recycled back to the head of the treatment plant.

Medfield

The Medfield POTW is the smallest of the three plants studied, treating an average of 1,300 cubic meters/day (0.35 mgd). The schematic flow diagram (Figure 4) shows that the Medfield treatment plant was not using primary sedimentation at the time of the study. Following mechanical aeration and secondary clarification, the effluent passes through a rapid sand filter and is then chlorinated before being discharged to the Charles River. The sludge from the secondary sedimentation is thickened by floatation and then vacuum filtered when needed. Usually, however, filtration is not needed and the sludge is discharged directly to the adjacent drying bed. Liquids from the floatation thickener and the vacuum filter are returned to the head of the treatment plant. For its

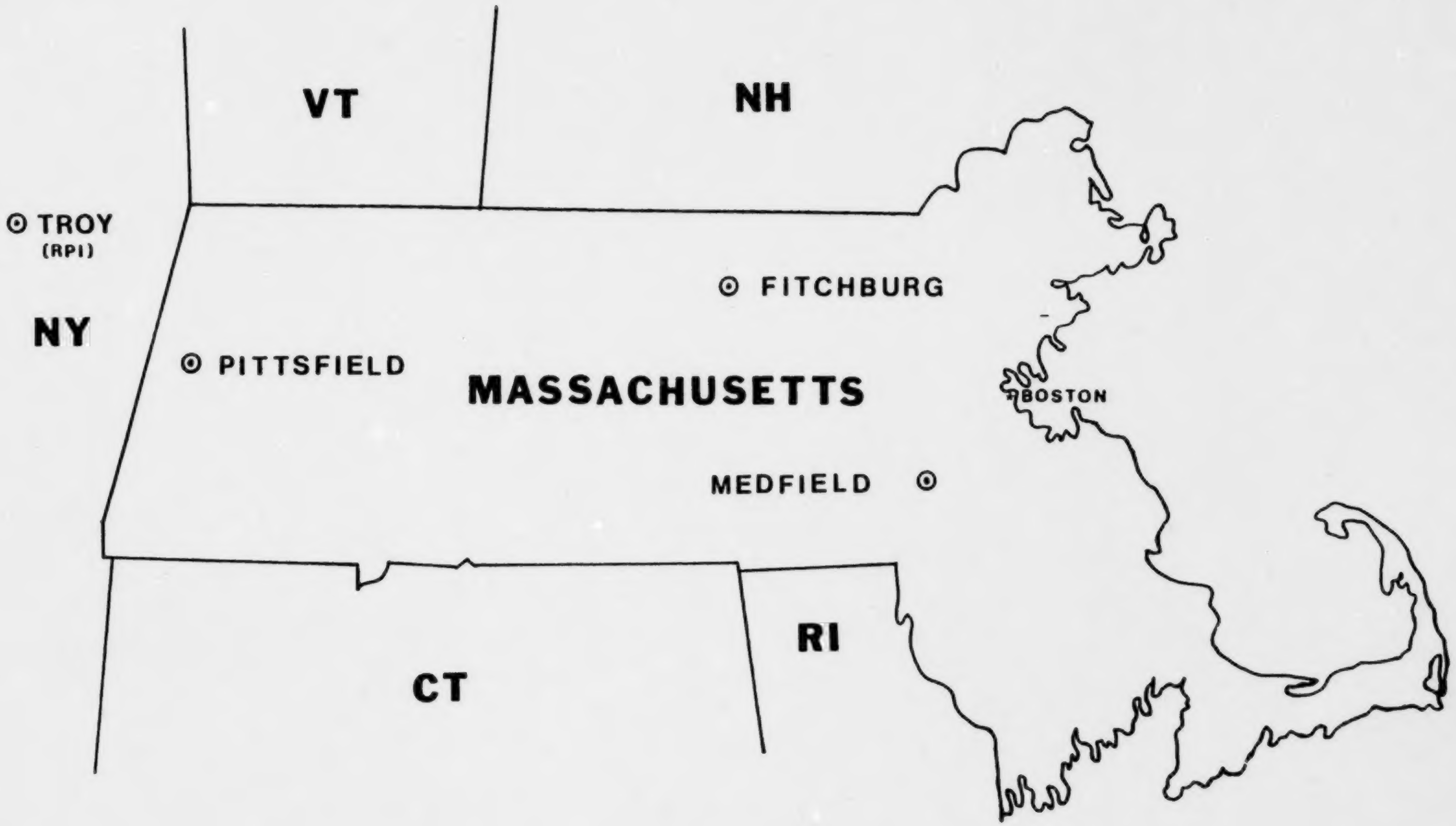
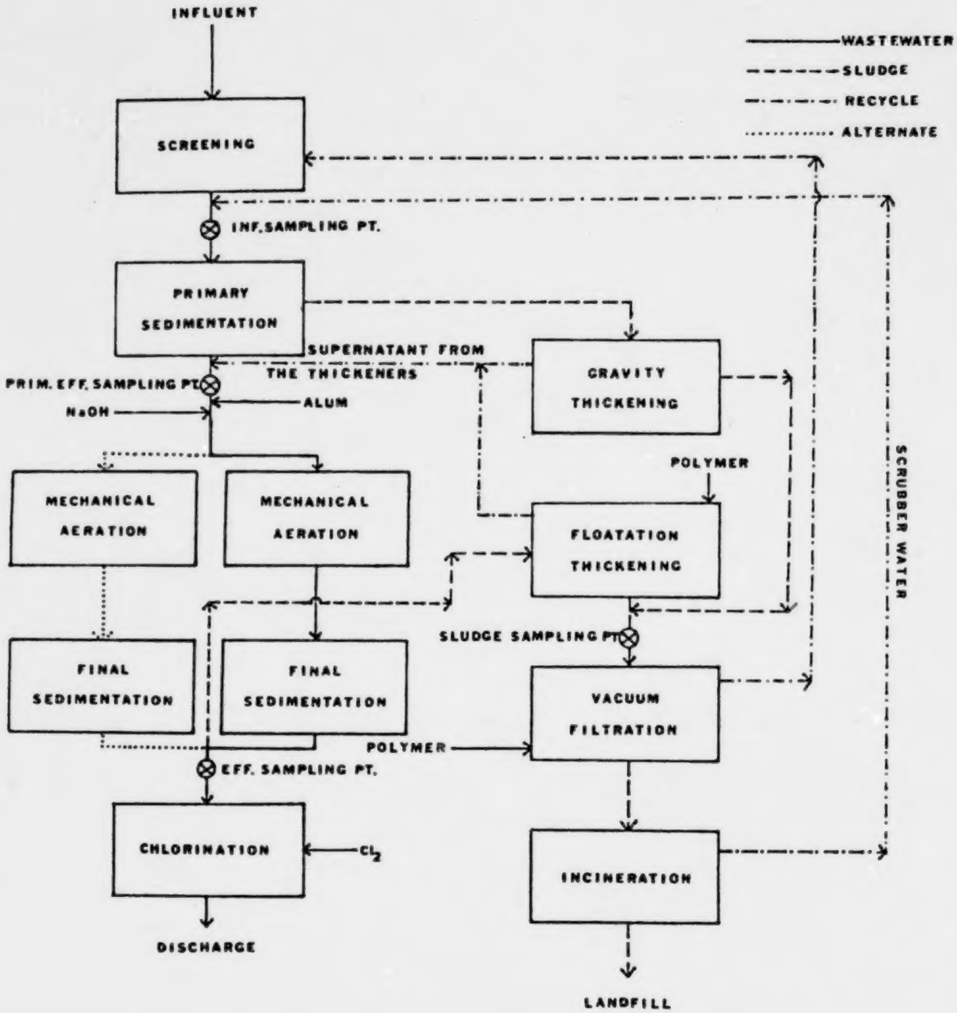


FIGURE 1: LOCATION OF TREATMENT PLANTS

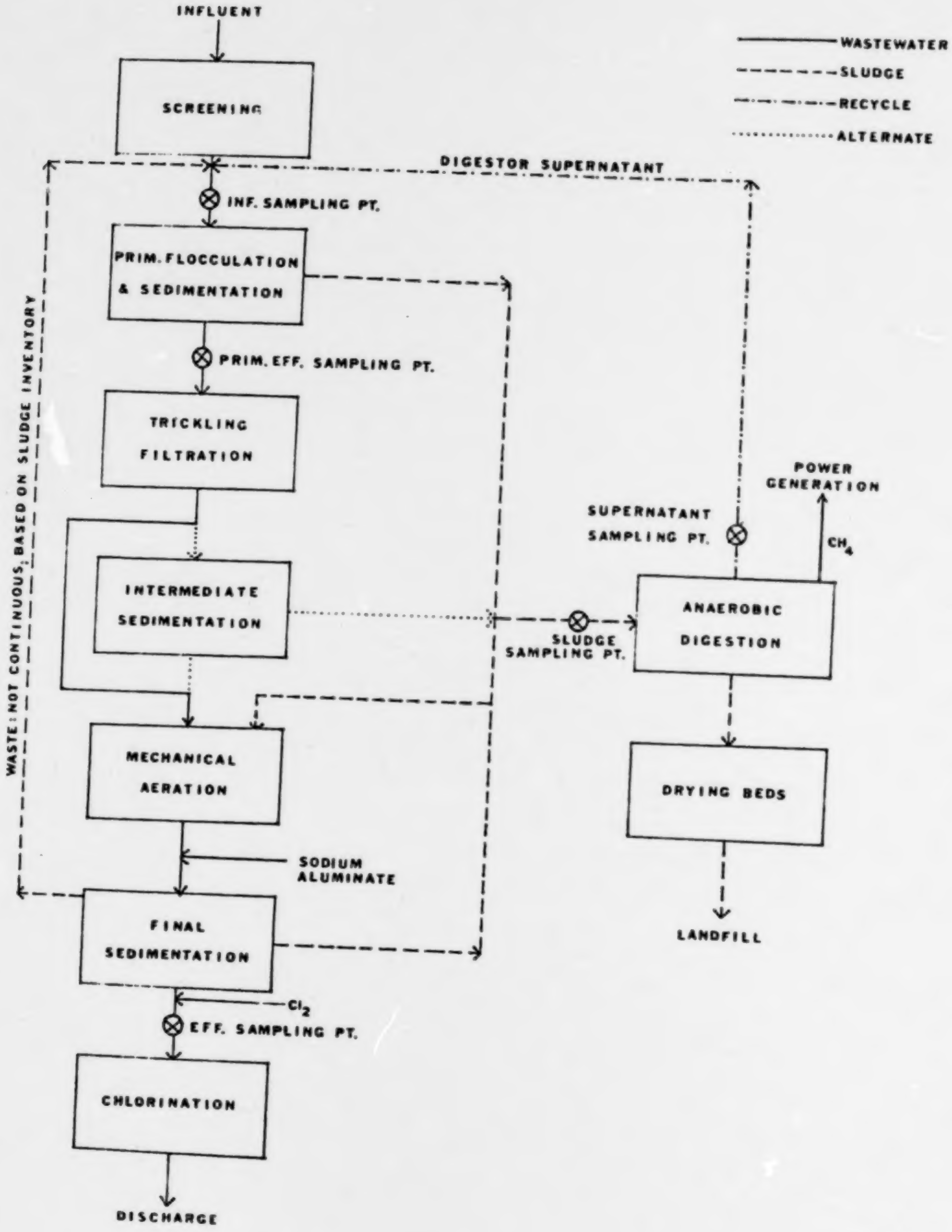
FIGURE 2



FLOW CHART OF WASTEWATER

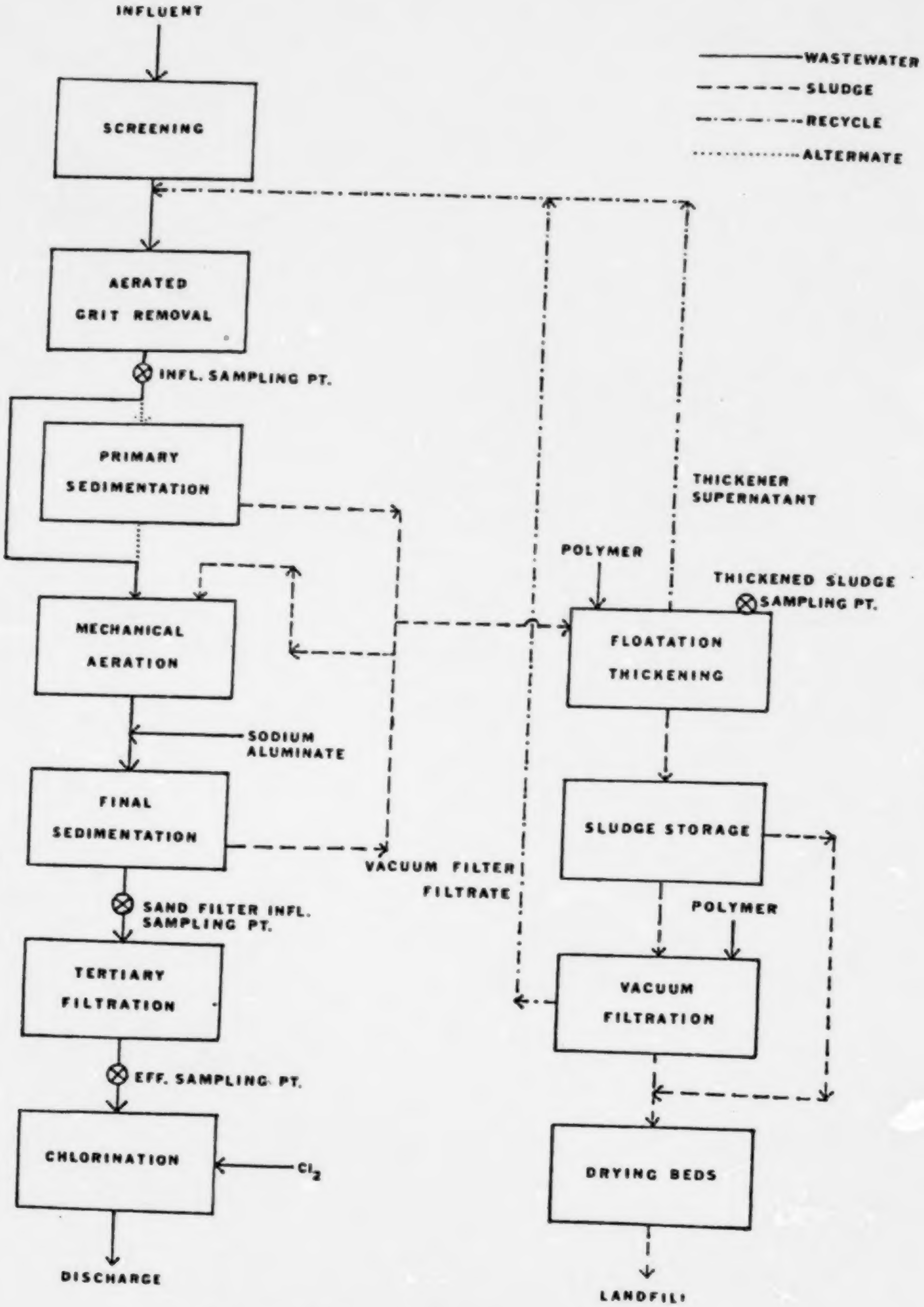
TREATMENT PLANT AT FITCHBURG, MA.

FIGURE 3



FLOW CHART OF WASTEWATER TREATMENT PLANT AT PITTSFIELD, MA.

FIGURE 4



FLOW CHART OF WASTEWATER TREATMENT PLANT AT MEDFIELD, MA.

phosphorus removal Medfield utilizes sodium aluminate, which is added prior to the secondary clarifier to a concentration of approximately 5.5 mg/L.

FIELD SAMPLING PROGRAM

As the collection of samples differed for each plant, each collection scheme will be discussed in turn. Three one-liter containers were collected; one for chemical testing, one for filtered metals, TOC, and phosphorus, and one for total metals, TOC, and phosphorus. The segregation of samples for different groups of tests reduced the chance of contamination with regard to trace metals. Samples were picked up from each treatment plant three times per week and transported back to the laboratory in Troy, New York. All composite samples were stored in acid washed polyethylene containers under refrigeration. In addition to the composite samples, a copy of the monthly laboratory log was obtained for each plant. The particular treatment parameters involved are discussed in the Results section.

Fitchburg

Daily, twenty-four hour composite samples were collected at Fitchburg in conjunction with the routine monitoring by plant personnel using a Sirco sampler (Sirco Products Ltd., Vancouver, B.C.). The samples were collected seven days a week from approximately 9:00 AM to 9:00 AM the following day. Composite samples were secured from the influent, the primary sedimentation effluent, and the final effluent as shown in Figure 2. Grab samples were taken from the combined sludge stream prior to vacuum filtration. The sampling period was from October 1 through December 3, 1982, and the addition of alum was discontinued on October 31,1982.

On October 20, the primary sedimentation effluent sampler was taken off line due to pump malfunction and was replaced on November 20, 1982 with a non-refrigerated sampler constructed from an N-CON ASM Automatic Sampling Module (N-CON Systems Co., Inc., New Rochelle, NY). The sampler was located outdoors so samples were kept at the cold ambient temperatures.

Pittsfield

Twenty-four hour composites were collected five days a week in conjunction with Pittsfield's routine monitoring program (9:00 AM Sunday to 9:00 AM Friday). Composite samples were taken from the influent, primary effluent, and the final effluent after chlorination. Grab samples were taken from the combined sludge and the digestor supernatant streams. The influent and effluent samplers were from Sirco while the primary sedimentation samples were collected using a non-refrigerated sampler from ISCO (ISCO, Lincoln,NE) which was located outdoors. All samples were collected in acid washed collection bottles.

The influent and effluent sampling was conducted from September 15 through November 15, 1982, while primary effluent sampling was performed between October 12 and November 15, 1982. The sodium aluminate addition was discontinued on October 11, 1982.

Medfield

The samples for Medfield were collected on the same five day schedule as for Pittsfield. Composite samples were taken from the influent stream and the final effluent stream which received the equivalent of tertiary treatment as a result of the sand filter. Since there was no primary sedimentation utilized during the time of the study, the third sample was taken from the influent to the sand filter, which is equivalent to the final effluent of the other two treatment plants. Thus, in all comparisons of the treatment plants the influent to the sand filter at Medfield was considered equivalent to the final effluent from Pittsfield and Fitchburg, and the final effluent at Medfield was considered equivalent to tertiary treatment. The influent and effluent samples were collected in unrefrigerated ISCO samplers (ISCO, Lincoln,NE), located outdoors, while the sand filter influent was collected in a non-refrigerated N-CON sampler. This sampler was in an unheated room where the sand filter is located. Collection bottles were acid washed on a weekly basis.

Sampling of the influent and final effluent stream was conducted from October 1 through December 15, 1982, while the sand filter influent was sampled from November 4 to December 15, 1982. The sodium aluminate addition was discontinued on November 15.

PRELIMINARY TREATMENT OF SAMPLES FOR LABORATORY ANALYSIS

On the same day samples were received in the laboratory the samples were pretreated for storage until they could be analyzed for the metals, TOC, and phosphorus. Samples for total metals were acidified to a pH 2 using 4 ml/L of ultrapure Ultrex nitric acid (J.T. Baker Chemical Co., Phillipsburg, NJ). The samples were then stored at 4°C until analyzed. Sludge samples were preserved by refrigeration only.

For the total TOC and phosphorus, approximately 20 ml aliquots were placed in individual, pre-labeled borosilicate glass test tubes and acidified to pH 2 using one drop of hydrochloric acid from a one milliliter pipette. The test tube was covered with parafilm and stored at 4°C until analysis was conducted.

The samples allocated for the filterable (soluble) fraction were allowed to settle to permit greater filtering capacity. For filterable TOC and phosphorus, an aliquot of settled sample was filtered through a 0.45-um non-gridded filter (Gelman GN-6, Gelman Sciences, Inc., Ann Arbor, MI) using a hydrochloric acid washed all-glass filtering apparatus (Millipore Corp., Bedford, MA). Approximately twenty mL of the filtered samples were placed into individual pre-labeled borosilicate glass test tubes, and acidified and stored in the same manner as the samples for total parameters. The filtration apparatus was acid washed between each sample. After completing all the filtration for TOC and phosphorus the filter apparatus was washed with nitric acid and used to filter samples for filtered metal analyses.

It was calculated that between 400 and 500 mL of filtered sewage would be needed for the metals analyses, necessitating a pre-filtering step before the 0.45-um filter. Another criterion was that the filters had to be metal free with a neutral charge to limit the adsorption or desorption of metals during filtration. The EPA (Hannah, personal communication) recommended using a 9.1-cm Whatman 934-AH glass microfibre filter in the prefiltering step. Although this removed the larger particles, the filtration through the 0.45-um filter was still a tedious undertaking. The following filter combination was finally derived after consultation with a representative of Gelman Sciences, Inc. A Type A/E glass fiber pre-filter, followed by a 0.8-um GN-4, over the 0.45um GN-6 was found to give the best results. It was found that, using this combination, the 0.45-um filter usually needed to be changed only once during each sample filtration. However, in some cases, such as influent samples, the prefilter had to be changed.

The final filtering scheme for the filtered metals analysis involved filtering the sample through a 9.1-cm glass fiber filter mounted in a ceramic filter holder followed by filtering through a Type A/E, GN-4, GN-6 combination mounted in a Millipore filter apparatus. The sample was then placed in a pre-labeled polyethylene container, acidified (4 mL of ultrapure nitric acid per liter) and stored at 4°C until analysis.

LABORATORY ANALYSES

The treatment plant parameters were analyzed in a separate laboratory from that used for the preliminary treatment steps to avoid cross contamination of samples. Biochemical oxygen demand (BOD) and total filterable residue were run within twenty four hours of collection. These analyses were run on only the samples that were collected the day the samples were picked up at the treatment plants. As mentioned before, samples for total organic carbon and phosphorus were acidified and stored until analyzed. Phosphorus was run within two months of collection and TOC within five months of collection. Total organic carbon and phosphorus were run on all the samples.

Biochemical oxygen demand was determined according to the 15th Edition of Standard Methods (APHA et al., 1981).

Total organic carbon was measured using a Beckman 915A Total Organic Carbon Analyzer (Beckman Instruments, Palo Alto, CA) as given in Standard Methods (APHA et al., 1981).

Total phosphorus was determined on both the total sample fraction and the filtered fraction using a persulfate digestion followed by the stannous chloride method of phosphorus determination (APHA et al., 1981). Total phosphorus refers to phosphorus in the total sample, and soluble phosphorus refers to the total phosphorus in the filtrate.

Total filterable residue (suspended solids) was determined by filtering the sample through a glass fiber filter which was then dried at 103-105°C according to Standard Methods (APHA et al., 1981).

The metal analyses and digestions were performed according to Methods for Chemical Analysis of Water and Wastes (EPA, 1979) and Analytical Methods for Atomic Absorption Spectrophotometry (Perkin-Elmer, 1971), with reference to Standard Methods (APHA et al., 1981). Table 9 gives a brief summary of the analytical method used for each metal.

All nonfiltered sewage, sludge and supernatant samples were digested before all metals analyses, except for mercury. Each metal analysis was characterized by what digestion technique was needed (See Table 9), after which all the samples requiring that technique were digested together and stored at 4°C in polyethylene containers before any further analysis. Samples were digested in groups of approximately twenty with a blank digested for each group. Aluminum, antimony, beryllium, cadmium, chromium, copper, lead, nickel, silver, thallium, and zinc were digested using nitric acid while arsenic and selenium underwent a nitric acid-hydrogen peroxide digestion. The originally recommended hydrochloric acid step in the antimony digestion (EPA, 1979) was omitted after consulting with Perkin-Elmer (personal communication). This allowed the antimony to be digested along with the nitric acid digestion group. Table 10 illustrates the increased recovery found when digesting duplicate samples with and without the hydrochloric acid step and the matrix results confirm that the antimony is being recovered, rather than matrix effects causing the increased recovery.

Analyses executed using the furnace method were performed on a Perkin-Elmer 303 Atomic Absorption Spectrophotometer with a matching HG-2000 graphite furnace (Perkin-Elmer, Norwalk,CT) in a laboratory used exclusively for trace metal analysis. Flame analyses and the Cold Vapor technique for mercury were performed on a Beckman 1301 Atomic Absorption Spectrophotometer (Beckman Instruments, Wakefield, MA) in a separate laboratory.

Mercury analyses were run within two weeks of sample collection with a standard curve run with each set of samples.

For analysis of both digested and filtered samples the samples were grouped according to metal with each group (metal) being completed before the next was started. A complete standard curve was run for every twenty-three samples along with the appropriate quality control for each metal. If the samples needed dilution to be within the limits of the linear portion of the standard curve, the dilutions were prepared in graduated borosilicate glass test tubes using ultrapure water from a Continental Water System (Continental Water Systems, Schenectedy, New York) at the time of the analysis.

The MIDAS (Michigan Interactive Data Analysis System) package was used on an IBM 3033 Computer for the statistical analysis of the obtained data. (MIDAS is a system for data

TABLE 9

METHODOLOGY FOR METAL ANALYSES

METAL	DIGESTION	ANALYTICAL METHOD	DETECTION LIMIT (ug/L)	REFERENCE
Ag	Nitric Acid	Furnace	2.00	EPA, 1979 Perkin-Elmer, 1971
Al	Nitric Acid	Furnace	20.0	EPA, 1979 Perkin-Elmer, 1971
As	Nitric Acid, Hyd. Peroxide	Furnace	5.0	EPA, 1979 Perkin-Elmer, 1971
Be	Nitric Acid	Furnace	0.5	EPA, 1979 Perkin-Elmer, 1971
Cd	Nitric Acid	Furnace	2.0	EPA, 1979 Perkin-Elmer, 1971
Cr	Nitric Acid	Furnace	3.0	EPA, 1979 Perkin-Elmer, 1971
Cu	Nitric Acid	Furnace	10.0	EPA, 1979 Perkin-Elmer, 1971
Hg	Cold Vapor Technique		0.20	APHA et al., 1981; EPA, 1979; Feldman, 1974; Greenburg et al., 1973
Ni	Nitric Acid	Flame	1000.0	EPA, 1979 Perkin-Elmer, 1971
Pb	Nitric Acid	Furnace	5.0	EPA, 1979 Perkin-Elmer, 1971
Sb	Nitric Acid	Furnace	10.0	EPA, 1979 Perkin-Elmer, 1971
Se	Nitric Acid, Hyd. Peroxide	Furnace	10.0	EPA, 1979 Perkin-Elmer, 1971
Tl	Nitric Acid	Furnace	5.0	EPA, 1979 Perkin-Elmer, 1971
Zn	Nitric Acid	Flame	300.0	EPA, 1979 Perkin-Elmer, 1971

TABLE 10

ANTIMONY DIGESTION COMPARISON TEST

(concentration in ug/L)

Conc. of sample digested with Nitric Acid alone	Conc. of sample digested with Hydrochloric Acid step
15.72	13.65
28.17	<10.00
27.13	13.65
21.95	15.72
15.72	<10.00
22.98	15.72
18.85	13.65
19.87	16.75
19.87	11.57

manipulation and statistical analysis written by the Statistical Research Laboratory of the University of Michigan).

QUALITY CONTROL

Quality control was performed on various aspects of the analyses to insure the analytical procedures used for this study were adequate. The effect of the filtration process on the metals concentration was determined. The precision and accuracy of the concentrations reported were also determined. Matrix effects were checked using the method of standard additions. Since the metals analyses were performed by several different people, each person ran the filtration quality control samples and the the EPA samples used for the accuracy analysis. This insured that the concentration values reported by any one person were consistent with those reported by the rest of the investigators.

Filter Apparatus

Quality control was conducted on the filter apparatus to determine if any soluble metal is lost or gained during the filtration process. A portion of a known standard was filtered by the same procedure used for sample filtration. The filtered and unfiltered portions were then analyzed and compared. The results are shown in Table 11.

Studies were not conducted on berylliunm and thallium because of the toxic nature of these metals and since their concentrations in all the wastewater samples were below the detectable limits.

The difference between the concentrations in the filtered and unfiltered samples for chromium, copper, lead, nickel and silver was less than the standard deviation of the individual concentration measurements, indicating no impact of filtration on these metals.

Multiple measurements were not made on the standards for mercury, but there appeared to be a loss of soluble mercury during the filtration process which is not proportional to the concentration. The loss appeared to be constant but with only two measurements done this cannot be stated with certainty.

There was also a loss of arsenic and aluminum during filtration (8.5 ug/L and 13.5 ug/L for arsenic and aluminum, respectively). For cadmium, selenium and total organic carbon, however, the filtered samples had a higher concentration than the unfiltered samples. The increase in cadmium through the filtering process may account for the fact that many of the wastewater samples analyzed had greater concentrations of soluble cadmium than total (unfiltered) cadmium.

The filtration process increased the TOC by an average of 3.5 mg/L. This more than doubled the total organic carbon of the samples having a low TOC concentration. The effect, however, diminished as the sample concentration increased since the amount of TOC gained from the filtration process remained constant.

TABLE 11

QUALITY CONTROL ON FILTER APPARATUS

(concentrations in ug/L)

METAL	STANDARD CONC.	NUMBER OF ANALYSES	UNFILTERED STD.		FILTERED STD.		DIFF.
			CONC.	SD	CONC.	SD	
Ag	5.0	5	7.71	0.98	7.01	0.81	-0.70
Al	100.0	3	119.30	5.10	105.70	1.04	-13.60
As	20.0	3	26.50	3.20	18.00	1.60	8.50
Cd	10.0	3	7.48	0.08	8.22	0.47	0.74
Cr	10.0	8	13.98	2.12	14.68	1.78	0.70
Cu	100.0	8	136.50	9.80	132.90	6.30	3.60
Hg	1.5	1	1.42	--	1.00	--	0.42
	2.0	1	2.27	--	1.94	--	0.33
Ni	1000	3	1027	310	1019	219	9.00
Pb	20.0	12	19.50	2.10	25.20	8.20	5.70
Se	30.0	3	20.30	4.10	25.90	3.80	5.60
Zn	300.0	3	<300.0	--	<300.0	--	--
TOC	--	3	3.64	0.35	8.42	1.46	4.78
	--	3	77.51	3.90	79.72	3.92	2.21

NOTE : TOC concentrations are in ppm.

Precision

Quality control was also conducted on the precision of the metal analyses. Precision was measured by performing multiple analyses of several standards to obtain a mean concentration and standard deviation. The precision was then obtained by dividing the standard deviation by the mean for each standard. The results are shown in Table 12.

Accuracy of Analyses

To test the accuracy of the metals analyses, Water Pollution Quality Control Samples were obtained from the Environmental Protection Agency(EPA). The results of our analyses of the samples and the true values given by the EPA are shown in Table 13. Antimony, silver, and thallium were not present in the EPA samples and the nickel concentration in all three samples was below the detection limit. Therefore, these metals are not included in the table.

There was a two orders of magnitude difference in the cadmium concentration reported for sample 4 and the value obtained in our lab. For all other metals the concentrations in sample 4 were the lowest value of the three samples analyzed, whereas for cadmium it was the highest. For this reason it is believed that the true value of 250 ug/L is in error, perhaps a typographical error. A value of 2.50 ug/L appears to be the correct value.

For most cases our results fall within the 95% confidence interval for each value. The major exceptions are aluminum, cadmium, and copper. Our values are consistently higher than the EPA values for these three metals. This could be attributed to analytical error or possible contamination of the samples. Since all values were consistently higher it is assumed that our values for the sewage samples may all be high, but since all samples are compared relative to other samples this is not a critical problem.

Standard Additions

The method of standard additions as described in Methods for Chemical Analysis of Water and Wastes (EPA,1979) was performed for each metal to ensure that there was no matrix interference. The results of these tests are shown in Table 14. The results show that there is little or no matrix effect for any of the metals.

Summary

The quality control showed that in general the analytical procedures used for this project are acceptable. The absolute values for the concentration of a few metals may be reported as higher or lower than the true value. However, the precision and the standard deviations based upom the multiple analysis of the filtration and EPA quality control samples indicate that the concentrations obtained are reproducible. Since this study

TABLE 12

ANALYTICAL RESULTS OF INTERLAB QUALITY CONTROL : PRECISION

(concentrations in ug/L)

METAL		I	II	III	IV	V	VI
Ag	Conc.	10.0	20.0	30.0	40.0	50.0	
	Mean	9.9	20.3	29.8	42.2	48.6	
	Precision(%)	1.3	1.1	0.4	8.3	5.5	
Al	Conc.	20.0	50.0	80.0	100.0	200.0	
	Mean	20.4	51.7	71.3	102.2	200.1	
	Precision(%)	11.5	13.8	13.3	5.2	2.1	
As	Conc.	5.0	10.0	30.0	50.0	80.0	100.0
	Mean	5.5	10.5	30.2	46.9	85.3	96.4
	Precision(%)	15.8	25.0	0.0	8.5	2.0	0.9
Be	Conc.	0.5	1.0	2.0	3.0	4.0	
	Mean	0.34	1.0	2.2	3.1	3.9	
	Precision(%)	3.4	1.2	2.1	1.7	3.4	
Cd	Conc.	1.0	3.0	5.0	8.0		
	Mean	1.1	2.9	4.7	8.7		
	Precision(%)	7.6	3.8	3.7	2.9		
Cr	Conc.	3.0	5.0	10.0	30.0	50.0	
	Mean	2.7	4.6	10.4	31.1	51.5	
	Precision(%)	9.2	5.2	0.0	5.6	2.2	
Cu	Conc.	20.0	50.0	100.0	200.0		
	Mean	17.0	63.1	97.4	194.2		
	Precision(%)	0.0	5.9	4.1	5.4		
Hg	Conc.	0.10	0.20	0.50	1.00	5.00	
	Mean	0.11	0.18	0.58	0.96	5.00	
	Precision(%)	0.0	0.0	8.6	10.3	2.0	
Ni	Conc.	1000	3000	5000			
	Mean	1033	2930	5037			
	Precision(%)	11.2	0.0	2.3			
Pb	Conc.	10.0	50.0	80.0	100.0	150.0	200.0
	Mean	12.3	48.2	79.3	101.4	152.9	193.1
	Precision(%)	22.3	18.1	6.1	9.9	7.0	6.2
Sb	Conc.	10.0	20.0	30.0	40.0		
	Mean	8.8	21.7	30.8	38.7		
	Precision(%)	14.1	8.7	8.4	5.6		
Se	Conc.	10.0	30.0	50.0	80.0	100.0	
	Mean	9.7	29.8	49.8	83.3	97.2	
	Precision(%)	49.9	16.1	9.6	5.1	1.9	
Tl	Conc.	1.0	2.0	5.0	8.0	10.0	20.0
	Mean	0.6	2.7	4.7	8.3	10.7	19.4
	Precision(%)	42.0	0.0	8.5	0.0	0.0	1.2
Zn	Conc.	300	500	1000	3000		
	Mean	260	580	960	2970		
	Precision(%)	36.9	0.0	9.4	5.7		

TABLE 13

ANALYTICAL RESULTS OF EPA QUALITY CONTROL SAMPLES

(concentrations in ug/L)

					RPI RESULTS	
METAL	S.NO.	TRUE VALUE	EPA MEAN	95% CONF.INT.	MEAN	SD
Al	4	60	83.9	45.7-122	125.7	1.2
	5	450	460	341-579	662.0	104
	6	800	819	682-956	1220.0	34
As	4	22	23.1	18.7-27.5	15.8	2.5
	5	60	56.6	37.0-76.2	53.8	2.6
	6	300	300	207-393	275.6	16.4
Be	4	20	20.5	16.1-24.9	22.1	0.8
	5	250	249	216-282	246.3	34.6
	6	900	894	810-978	1061.7	34.4
Cd	4	250	238	203-273	3.4	2.0
	5	13	12.3	9.5-15.1	28.7	2.6
	6	70	65.6	54.4-76.8	83.9	1.5
Cr	4	10	10.2	8.0-12.4	10.4	1.4
	5	80	78.0	60.2-95.8	80.6	3.5
	6	250	242	196-288	277.5	13.7
Cu	4	11	11.3	6.1-16.5	22.1	2.3
	5	50	49.4	42.4-56.4	71.2	5.7
	6	350	346	311-381	474.1	50.6
Hg	4	0.75	0.76	0.32-1.20	0.8	--
	5	3.5	3.3	1.6-5.0	2.75	--
	6	8.0	7.5	4.0-11.0	5.0	--
Pb	4	24	24.7	17.3-32.1	18.1	1.9
	5	120	122	92.4-152	116.6	30.7
	6	400	399	345-453	454.2	48.9
Se	4	6.0	5.6	2.8-8.4	<10.0	--
	5	30	29.3	22.3-35.3	19.3	1.8
	6	50	48.0	31.6-64.4	32.9	3.8
Zn	4	16	17.1	9.7-24.5	<300	--
	5	80	78.3	64.9-91.7	<300	--
	6	400	396	352-440	530	60
TOC	4				3.64	0.35
	5				77.51	3.90
	6				43.90	0.79

NOTE : TOC concentrations are in ppm.

TABLE 14

METHOD OF STANDARD ADDITIONS

(concentrations in ug/L)

METAL	SAMPLE CONCENTRATION	CONC. CALCULATED BY THE METHOD OF STANDARD ADDITIONS
Ag	28.60	29.00
Al	77.40	16.00
As	29.25	31.50
Be	2.64	2.65
Cd	1.97	1.90
Cr	27.60	24.00
Cu	177.60	200.00
Hg	0.34	0.70
Ni	2.49	2.54
Pb	122.00	121.50
Sb	14.50	16.00
Se	13.31	11.00
Tl	1.92	2.00
Zn	2660	3100

is concerned primarily with metals removal, concentrations of metals in samples are evaluated relative to other sample concentrations; so, consistent results are of primary importance rather than absolute values.

SECTION 6

PRESENTATION AND DISCUSSION OF RESULTS

In many instances, concentrations of the thirteen metals on the priority pollutants list were less than the minimum reproducible detection limit of the instrument employed. All such values were reported as being at the minimum detectable limit rather than recording these values as zero (See Appendix A). The detection limits for the various elements studied are shown in Table 9. This means that in no instance could 100% removal be achieved (by calculation) since the lowest value recorded was always the minimum detectable limit. This must be kept in mind when interpreting removal and, especially, fractional removal data.

Three metals: nickel, thallium, and beryllium, were never present above their detection limits in the influent. Therefore, the extent of their removal in the treatment plants can not be ascertained and no evaluation can be made of the effect of addition of the aluminum salt on their removal. For the remaining determined constituents, the concentrations in the total and the soluble portions were compared for cases with and without the addition of the aluminum salt. The constituent removals as a result of primary treatment (except for Medfield), activated sludge treatment and for Medfield the sand filter were also calculated based on the influent concentration in each case and compared in a similar fashion. While calculating the removals, cases wherein a particular element was present at or below the detection limit in both the influent and effluent were ignored. If 'calculated', the removals in such cases would have been (wrongly) found to be zero and, if included, these would have incorporated a serious error in the descriptive statistics (mean, standard deviation, minimum and maximum) of the removal data.

At first glance, the addition of the aluminum salt appeared to increase metals removal, at least marginally, in most cases. The descriptive statistics for the various elements were determined separately for cases with and without the addition of aluminum salts. t-tests were performed (Miller and Freund) to test the hypothesis that the mean removal in both the cases was the same. It was found that, in a majority of cases, no conclusion could be made to the effect that the addition of the aluminum salt enhanced metal removal. This was because of the large standard deviation in the data. There were, however, a few cases in which the removal was statistically improved by the addition of the aluminum salt and yet others for which a similar conclusion could be made, but at a lower confidence level.

RESULTS

Silver

The results of the mean concentration of the silver analysis are summarized in Figure 5. Tabulated values of the descriptive statistics for concentration and removal are in Appendix B. At all the treatment plants, silver was largely present in the particulate form. The Fitchburg and Pittsfield treatment plants had more silver (on the order of 30 ug/L) in the influent than Medfield where the influent silver concentration was in the order of 10 ug/L. Good overall removal of both the total and the soluble silver was achieved at all the treatment plants with most effluent concentrations at or below the detection limit. The small standard deviations indicate that the daily silver removal at the three treatment plants was fairly constant. As Figure 5 indicates, the secondary treatment essentially removed all the silver at the three plants. Primary sedimentation was more effective at removing silver at Pittsfield (41-55 % removal) than at Fitchburg where primary removal averaged less than 11 %. Since most of the effluent concentrations were reduced to the detection limit even without aluminum salt addition, no conclusions can be made about the benefit of aluminum salt addition on the removal of silver.

Arsenic

Little measurable arsenic was present in the wastewater influent to the Fitchburg and Medfield treatment plants whereas the mean concentration detected in the influent stream at Pittsfield was generally in the range of 15-20 ug/L (See Figure 6 and Appendix A). The arsenic concentration in most of the effluents was at or below the detection limit even without the aluminum salt addition. Since the values were reported at the detection limit, the % removals thus calculated do not representnt the true picture and give values which could be much smaller than the actual removals. Therefore, the impact of aluminum salt addition could not be ascertained. Moreover, though the t-tests were done as a matter of routine with the calculated arsenic removals, it is obvious that it would be erroneous to give any credence to the results.

Cadmium

Cadmium was present in only small concentrations at Fitchburg and Medfield, with the mean influent concentration being approximately 5 ug/L, whereas a mean cadmium concentration of approximately 20 ug/L was observed in the influent at Pittsfield (Figure 7). One peculiarity was observed in the cadmium analyses in that the concentration in the filtered samples was found to be greater than that in the unfiltered samples in a remarkably large number of instances, consistent with the quality control results. A possible

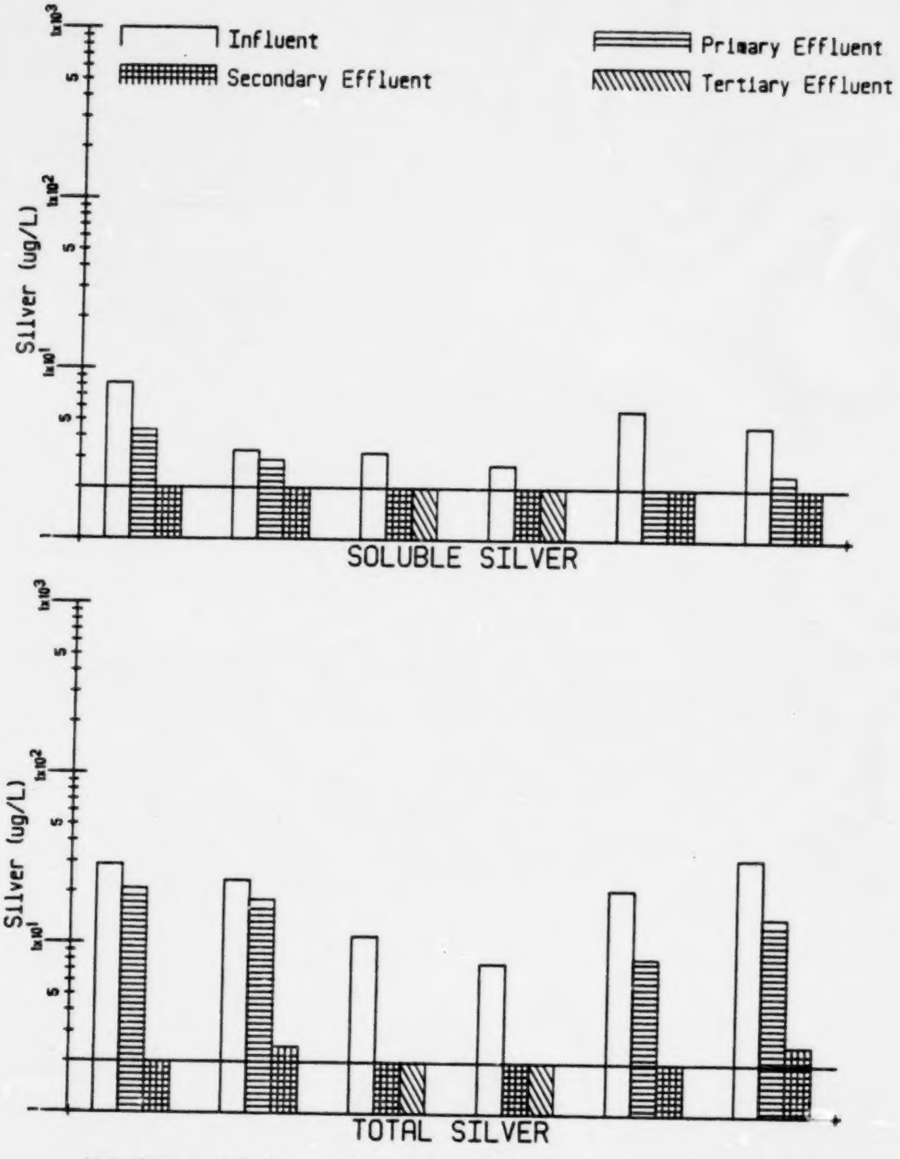


Figure 5: Mean Concentration of Silver in POTWs

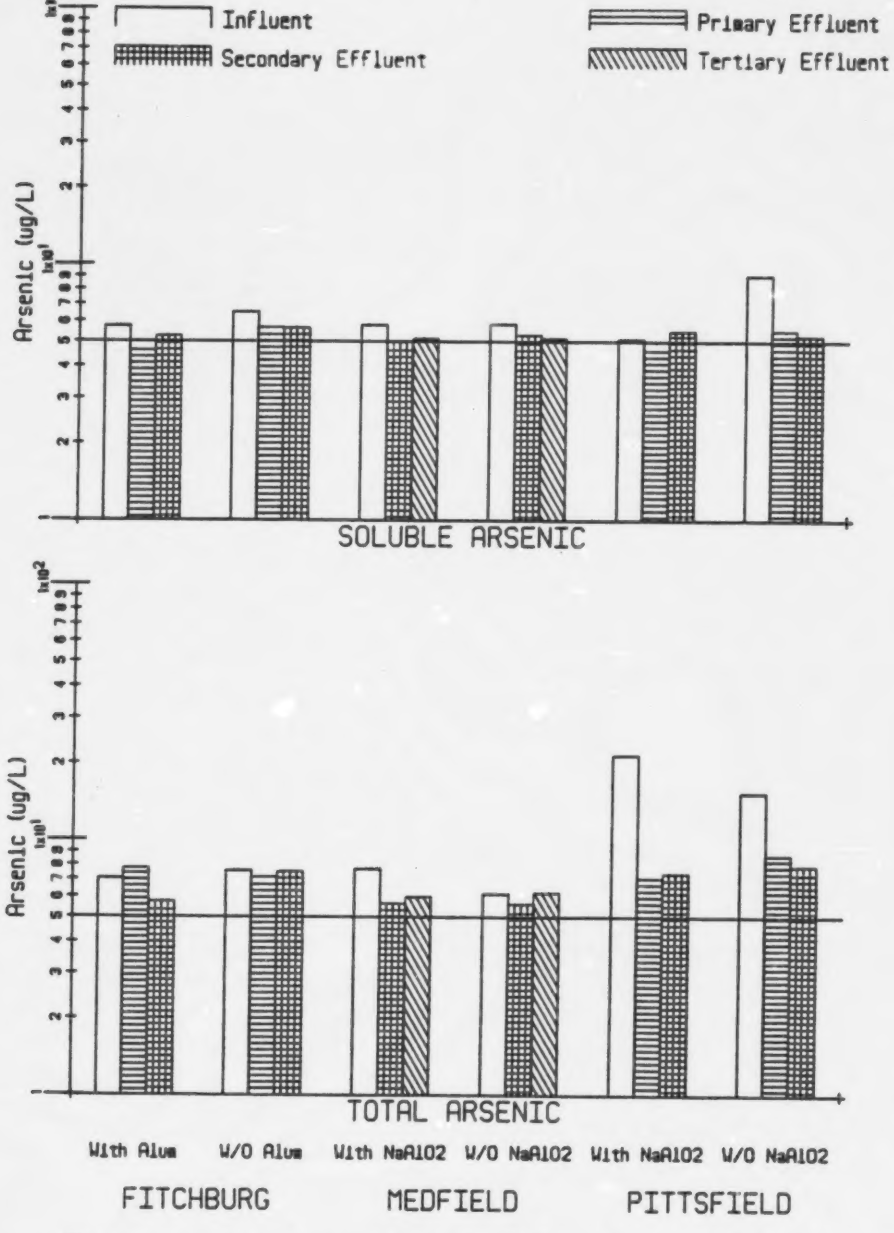


Figure 6: Mean Concentration of Arsenic in POTWs

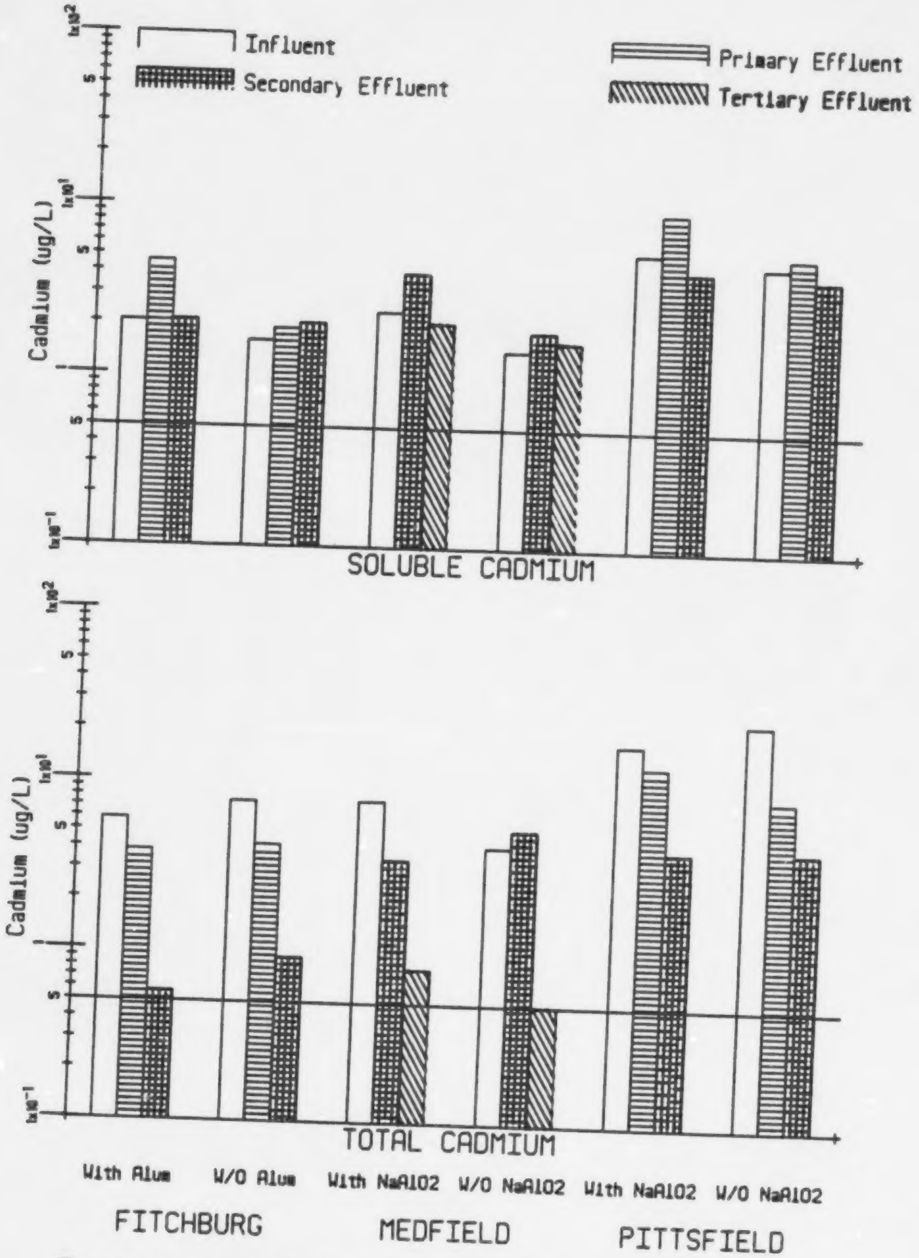


Figure 7: Mean Concentration of Cadmium in POTWs

explanation could be that some component, which is removed to varying degrees during the process of filtration, interferes with the cadmium analysis. This could also explain the observed higher soluble cadmium concentrations in the effluent samples than in the influent samples in certain instances. A batch of contaminated plasticware (in which the samples were stored during refrigeration) could be another possibility (EPA, 1971). However, the obtained values indicate a reasonably good (upwards of 70%) removal of the total cadmium. There was no statistical difference in cadmium removal with and without the added precipitant.

Chromium

Most of the chromium at all the three treatment plants was present in the particulate form as seen in Figure 8. The total influent chromium concentration at Fitchburg was much greater than that at the other two plants. Measurable amounts of soluble chromium were also detected at the the treatment plants with the values at Medfield being only marginally above the detection limit (See Appendix A). The primary treatment was essentially ineffective at removing chromium. At Medfield, the activated sludge process accounts for almost all the removal. Medfield and Pittsfield had lower total chromium concentrations in the effluent with the addition of the sodium aluminate. The mean overall removals for the period during the addition of the aluminum salt were higher than the mean overall removals when the salt was not added (See Appendix B), but a statistical conclusion could not be made to this effect at Fitchburg and Medfield because of the large standard deviation in the data. However, the statistical evidence indicates that the addition of sodium aluminate at Pittsfield was significant in enhancing the removal of chromium.

Copper

At all three treatment plants the mean levels of total copper in the influent were in the range of 500 ug/L, as shown in Figure 9, with the particulate form being dominant over the soluble form. Primary sedimentation removed little or no copper at Fitchburg and Pittsfield, where satisfactory removal was achieved during secondary treatment. However, good overall copper removal was achieved at all the treatment plants (76-93% removals). At both Fitchburg and Pittsfield, the addition of alum and sodium aluminate appeared to enhance copper removal as confirmed by the t-tests. At Medfield, there was a slightly greater mean removal of copper with the addition of sodium aluminate but the difference was only moderate and the standard deviation of the data large in comparison. Thus it cannot be affirmed that the sodium aluminate did improve the copper removal at Medfield.

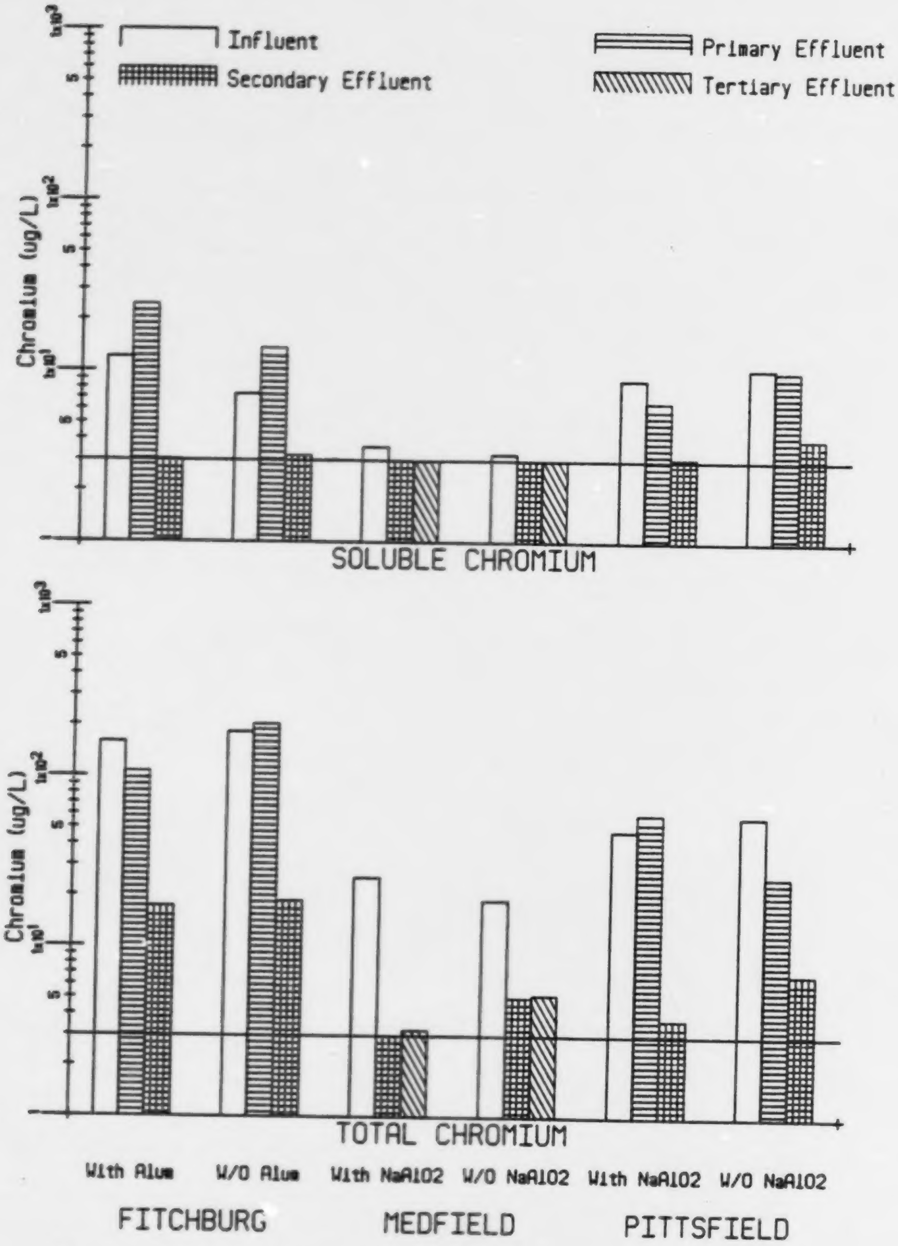


Figure 8: Mean Concentration of Chromium in POTWs

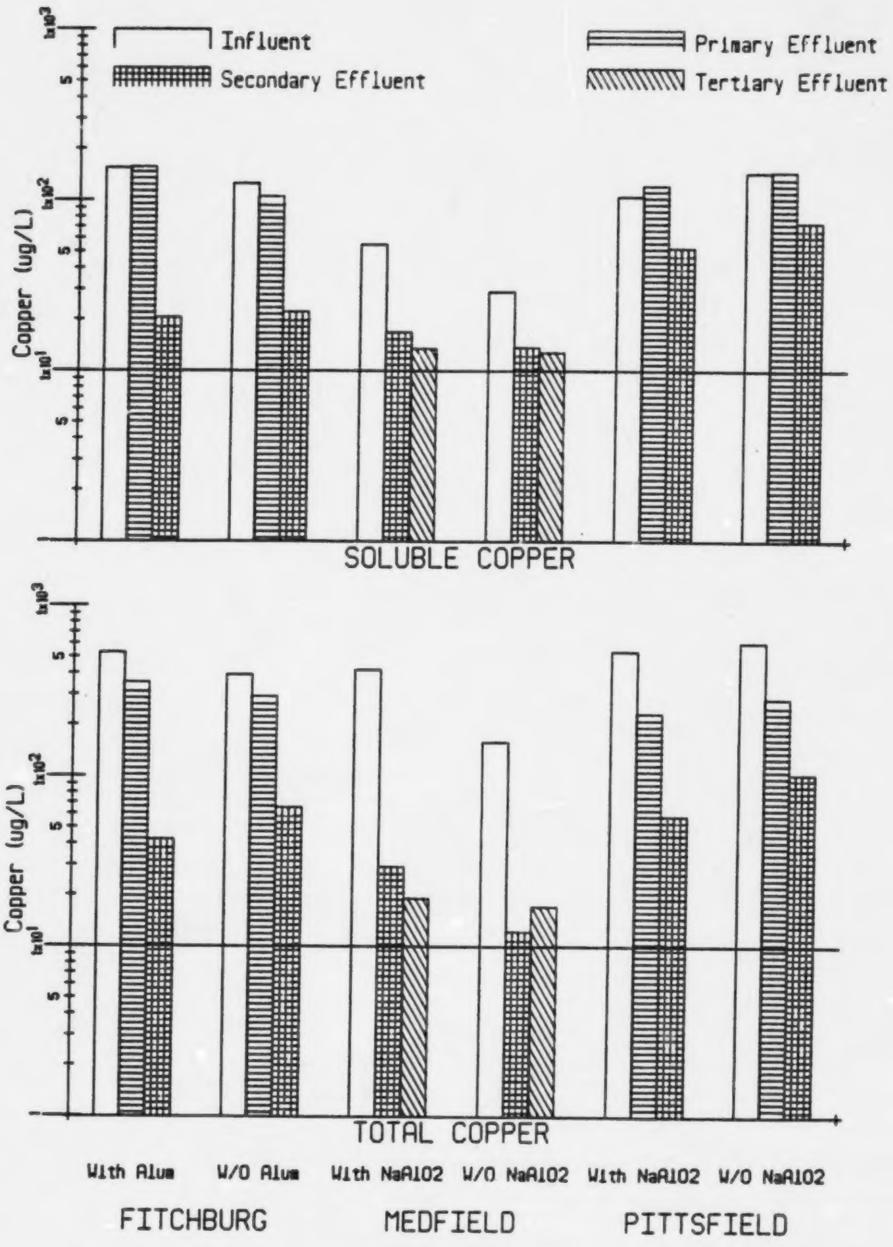


Figure 9: Mean Concentration of Copper in POTWs

Mercury

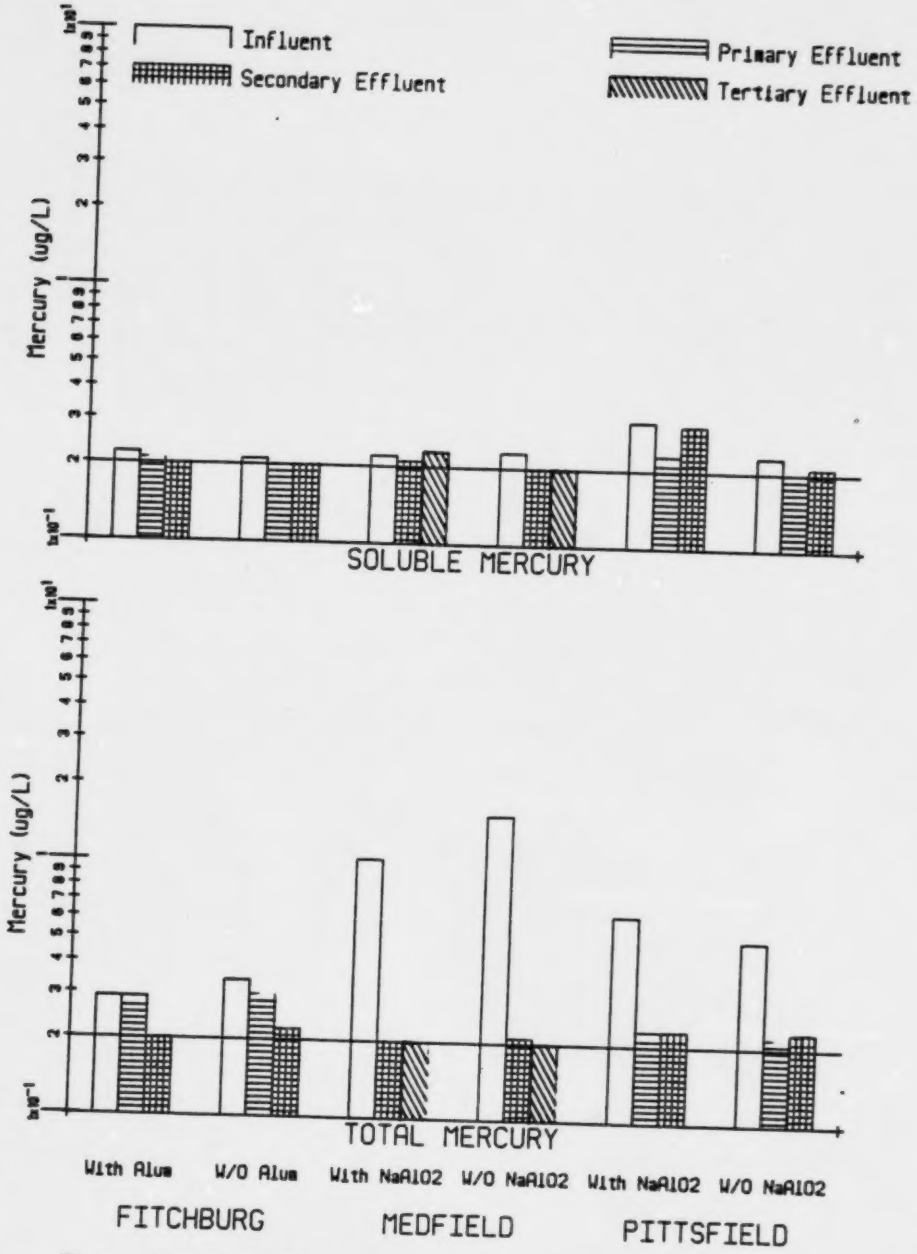
As is evident from Figure 10, soluble mercury was present at, or barely above, the detection limit at all the three plants sampled. Total mercury was present in only low concentrations at Fitchburg, but significant concentrations of total mercury were observed in the Medfield influent samples. Lower concentrations of particulate mercury were also determined in the Pittsfield influent. At Pittsfield essentially all the particulate mercury was removed in the primary sedimentation system. Since this removal occurs prior to the addition of the sodium aluminate, no removal attributable to the precipitant addition can be observed. Likewise, there was no significant difference in the mercury removal during and without alum addition at Fitchburg. The highest % removal of total mercury was achieved at Medfield with the activated sludge removing most of the metal. However, because most effluent concentrations were at the detection limit, no conclusions on the benefit of aluminum salt addition can be made.

Lead

High lead concentrations were observed at all three treatment plants with the amounts in the Fitchburg influent being much higher than those at the other two treatment plants. In summarizing the results of the lead analyses in Figure 11, a log scale has been used. In general, the soluble form constituted less than a tenth of the total lead present, though up to 50 ug/L of soluble lead was observed in the Fitchburg influent. The total lead in the influent to the Fitchburg treatment plant reached a high average value of over 800 ug/L whereas the mean influent concentrations at Medfield and Pittsfield varied between 60 and 110 ug/L. Only a small portion of the total lead was removed by primary sedimentation at Fitchburg but a significant amount (67-99 %) was removed by secondary treatment. At Pittsfield, primary treatment effected considerable lead removal (83-87%). In all cases, a higher % removal was observed for cases with aluminum salt addition but the variance of the data was also correspondingly great and the t-tests failed to show that the mean removal during alum/aluminate addition was statistically different (or greater) from the mean removal obtained without addition of aluminum salts.

Antimony

There was only a small amount of antimony in the three wastewater influents as seen in Figure 12. Medfield and Fitchburg averaged about 13-15 ug/L of antimony entering their plants while Pittsfield had about 18-20 ug/L in its influent. As with cadmium, though, there were numerous samples where the soluble concentrations reported were higher than the total concentrations. There were also many primary effluent soluble antimony concentrations which were not only greater than their



SOLUBLE MERCURY

TOTAL MERCURY

Figure 10: Mean Concentration of Mercury in POTWs

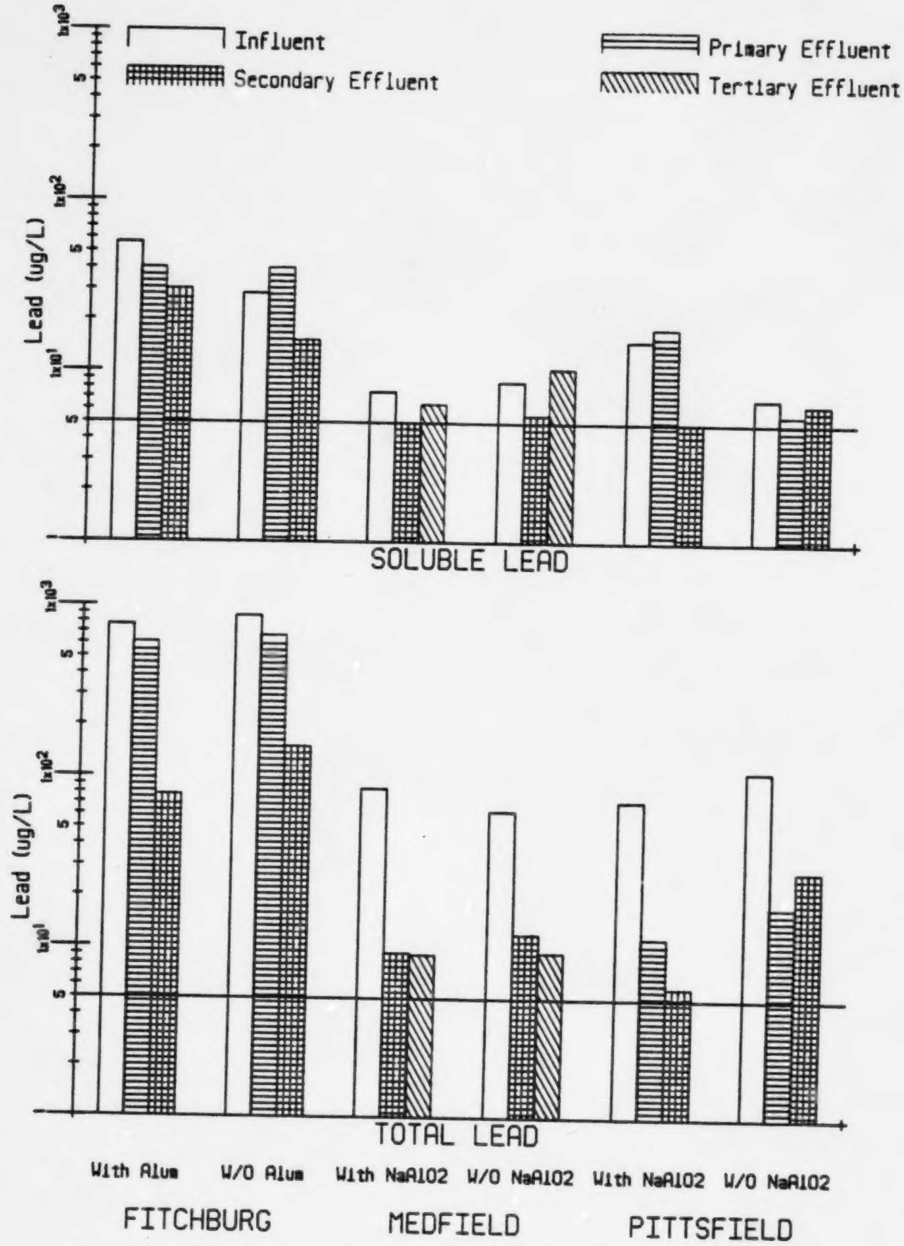


Figure 11: Mean Concentration of Lead in POTWs

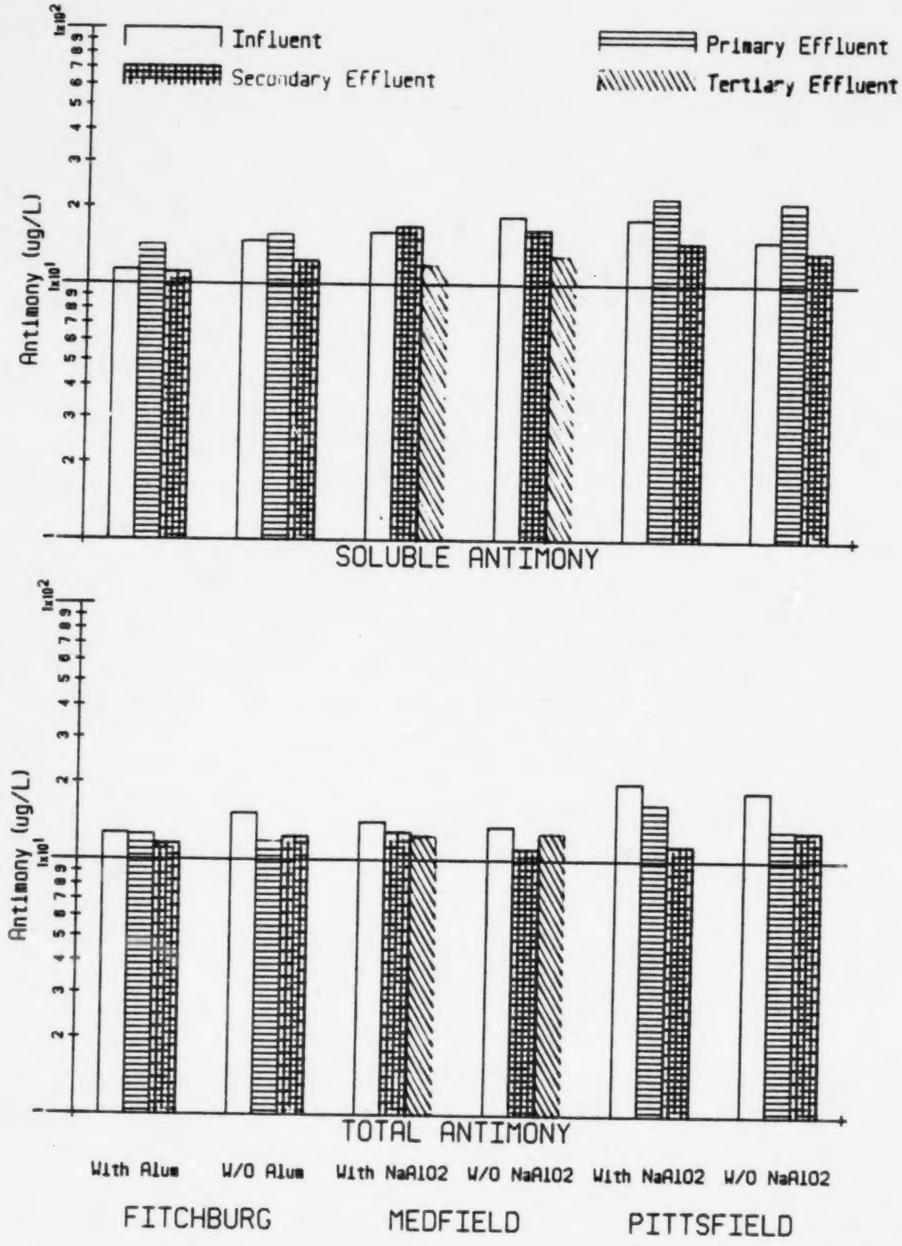


Figure 12: Mean Concentration of Antimony in POTWs

counterpart total metal concentrations but also greater than the influent concentrations. This could be due to some component that interferes with the antimony analyses which is present in the wastewater and is removed during the filtration process and also, to some extent, due to the effects of primary sedimentation. The values reported indicate a poor removal of antimony, with most of the overall removals reported at less than 10%. There is no indication that the addition of aluminum salts enhances antimony removal.

Selenium

Except in the Pittsfield influent samples, selenium was present at or below the detection limit in most cases. Occasionally, selenium concentratons of around 20 ug/L were observed in the Fitchburg and the Medfield influents while the mean selenium concentration in the Pittsfield influent was about 25 ug/L (See Figure 13). Some removal (27-44%) was achieved during primary sedimentation at Pittsfield, but because almost all of the effluent concentrations were below the detection limit (but reported at the detection limit as mentioned earlier), the true extent of secondary or overall removal of selenium could not be ascertained. Hence, the benefit of aluminum salt addition on selenium removal cannot be evaluated. The t-tests were done as a matter of routine, but the value of the test is questionable in this case.

Zinc

As shown in Figure 14, the presence of soluble zinc in concentrations above the detection limit was not observed in the influent of any of the treatment plants. It should be noted that the detection limit for zinc is high (300 ug/L) compared to the other metals so samples whose concentrations are reported at or below the detection limit could have significant amounts of zinc present. The total zinc concentration was also below the detection limit for all the plant effluents and many of the influent samples at Fitchburg and Medfield. As in the case of arsenic and selenium, any statistics on the calculated removal and results of any tests based on these statistics would be most unreliable and misleading. The impact of aluminum salt addition, therefore, cannot be determined.

Aluminum

In addition to the thirteen metals on the priority pollutants list, the samples taken from the three treatment plants were also analyzed for aluminum, TOC, and phosphorus. Aluminum was analyzed to ensure that the addition of aluminum salts did not cause an increase in aluminum in the effluent stream. The concentration of aluminum in the influent at Fitchburg and Medfield averaged about 1800-2500 ug/L (Figure 15), while at Pittsfield the influent concentration during aluminum salt addition was about ten times those values. When

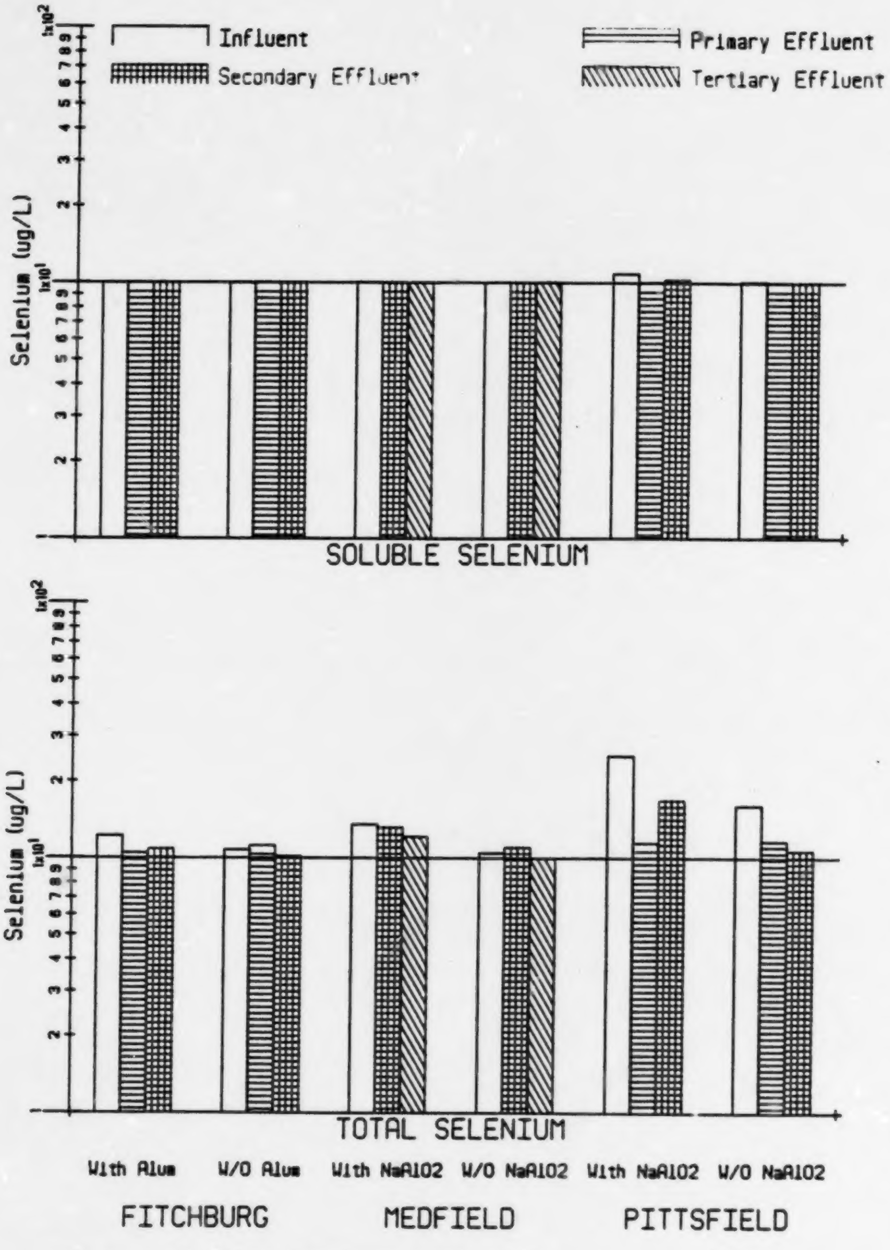


Figure 13 Mean Concentration of Selenium in POTWs

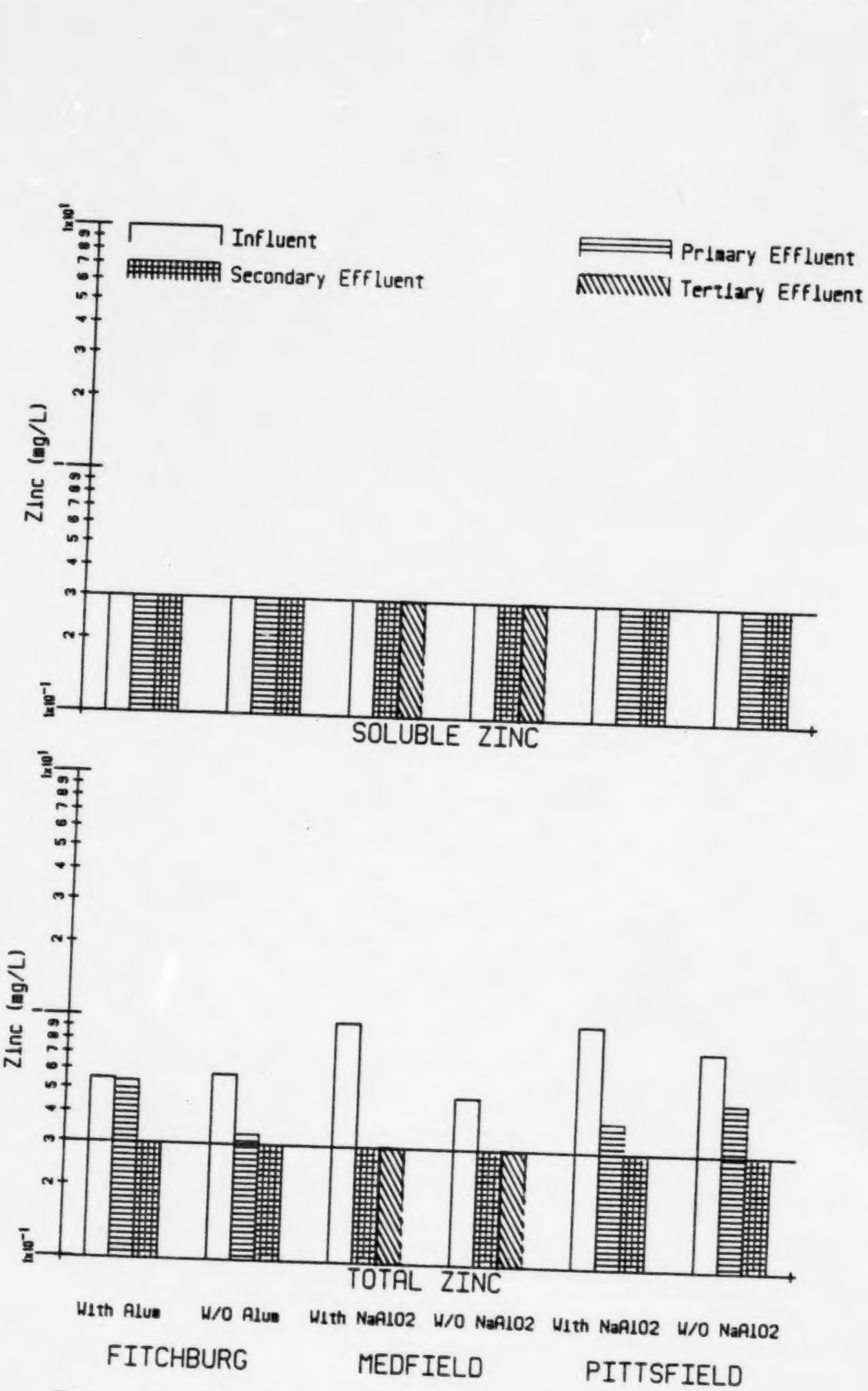


Figure 14: Mean Concentration of Zinc in POTWs

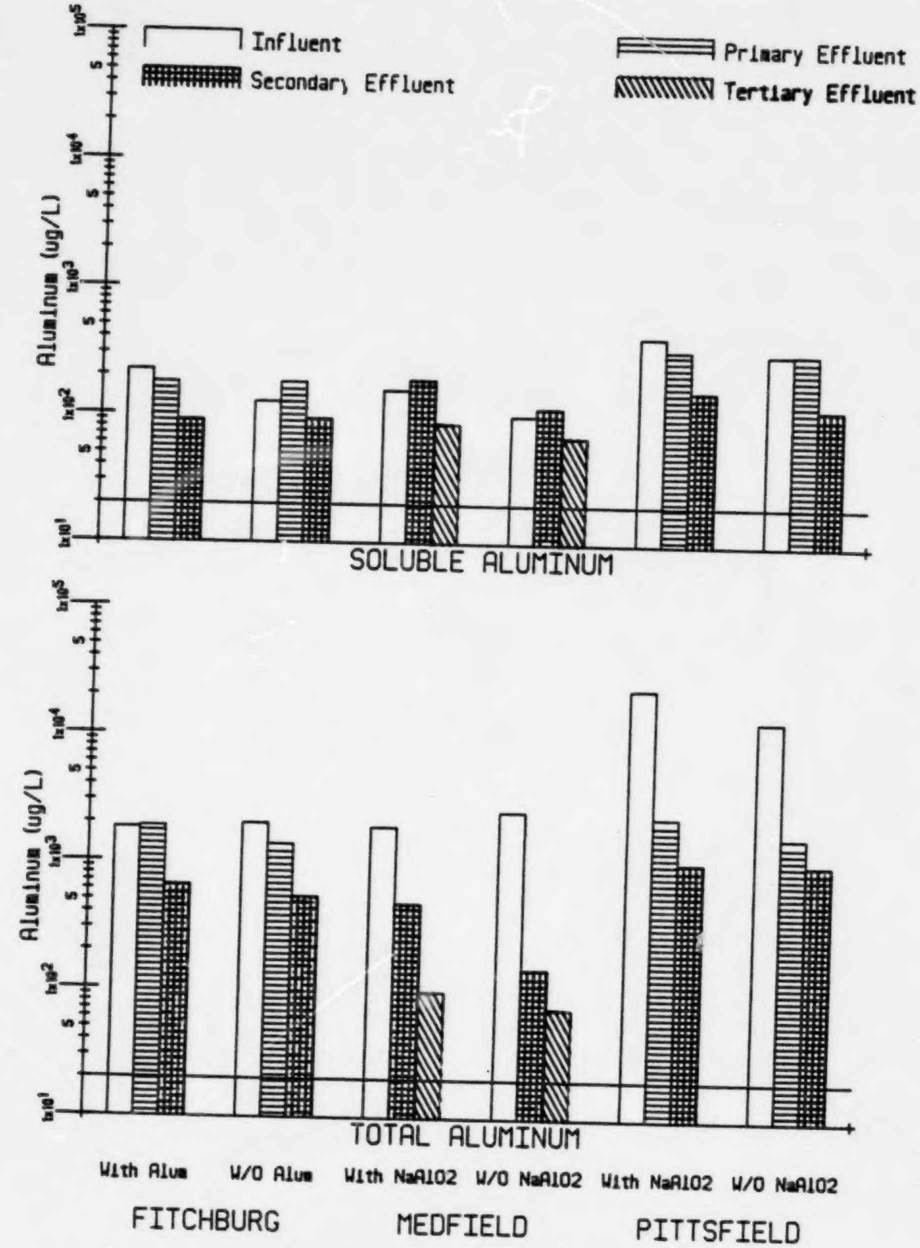


Figure 15: Mean Concentration of Aluminum in POTWs

the addition of the salts was discontinued the concentration of aluminum in the Pittsfield influent dropped to about 13000 ug/L. The high concentration at Pittsfield is probably due to the recycle of the anaerobic digestor supernatant stream back to the head of the plant. A large percentage (85%) of this is removed during primary sedimentation at Pittsfield. The net removal of aluminum through all the plants remains fairly constant during and without the addition of aluminum salts, indicating that the treatment processes are capable of removing aluminum in concentrations in excess of what is encountered normally.

Total Organic Carbon

A great deal of variation was observed in the daily total organic carbon loading at all the treatment plants (Figure 16). Concentrations ranged from 10 to 200 mg/L in the raw wastewater streams for the total samples and from 12 to 24 mg/L for the soluble fraction. All the plants appeared to be removing the total carbon more effectively than they removed carbon in the soluble form. At Medfield, essentially all the removal of both the total and the soluble carbon was a result of the activated sludge process with the tertiary treatment bringing about little additional removal. The primary sedimentation at Fitchburg and Pittsfield resulted in no reduction in either total or soluble carbon but satisfactory removal was achieved by the secondary treatment. Overall removals for the three plants ranged from 75-89% for the total carbon and 48-72% for the soluble portion. There was no statistical difference in the carbon removal with and without the addition of aluminum salts.

Phosphorus

The influent total phosphorus concentrations at all the three treatment plants were generally in the range of 4-7 mg/L (See Figure 17). At Fitchburg and Medfield, the soluble fraction constituted over two-thirds of the total phosphorus whereas the particulate form contributed marginally more than the soluble form at Pittsfield. Most of the phosphorus removed, both soluble and total, was removed during secondary treatment at all three plants. As expected, the addition of aluminum salts showed a significant increase in phosphorus reomoval and this fact was corroborated by the t-tests. Removals ranged from 83-89% for total phosphorus during alum/aluminate addition and only from 16-45% when the addition of aluminum salts was discontinued.

CORRELATION OF METALS REMOVAL TO TREATMENT PARAMETERS

Correlation coefficients were calculated to determine the relationship between the removal of heavy metals and the reduction in various process parameters. The parameters used for comparison include phosphorus concentration (P), total suspended solids (TSS), total organic carbon (TOC), and

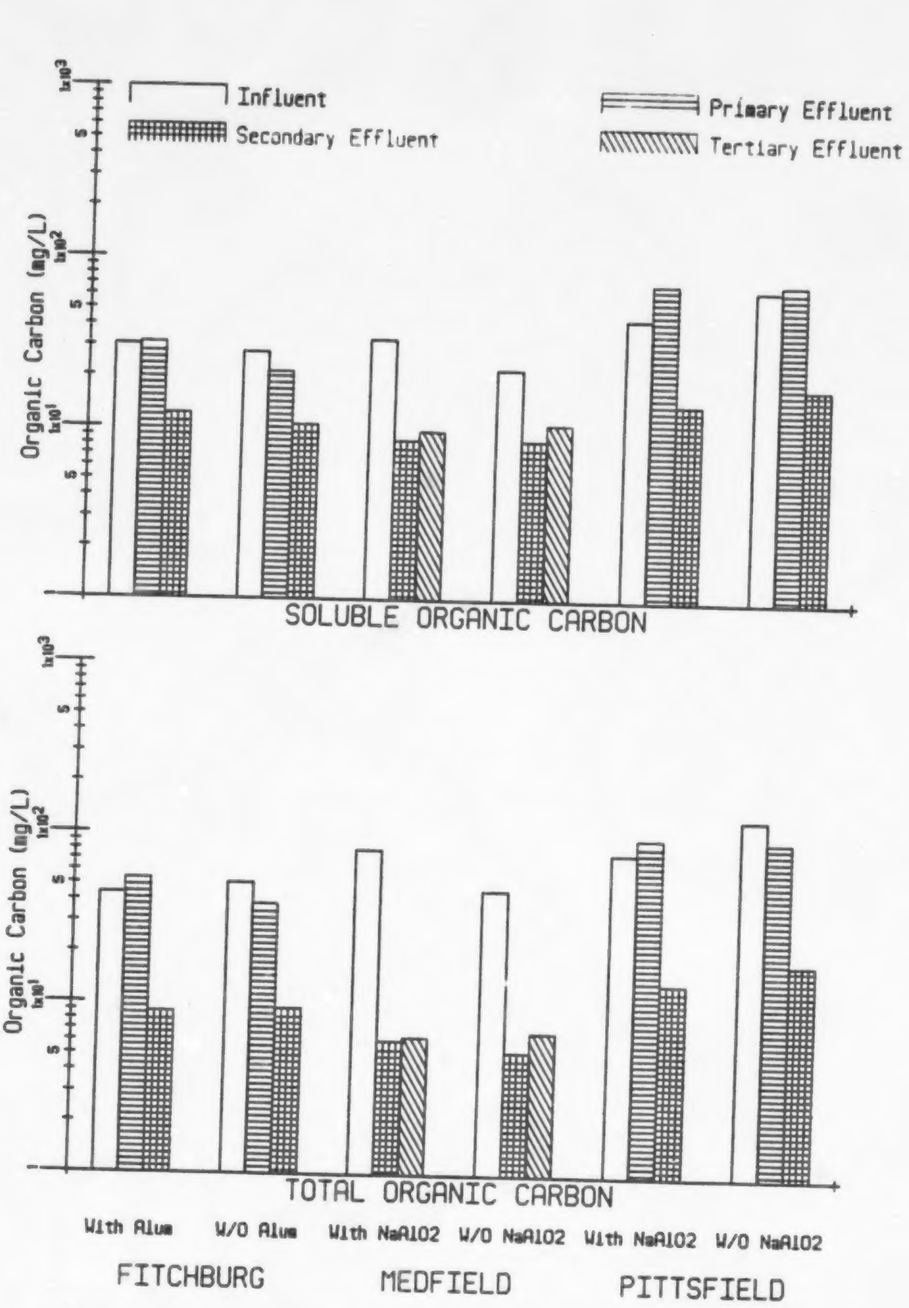


Figure 16 Mean Concentration of Organic Carbon in POTWs

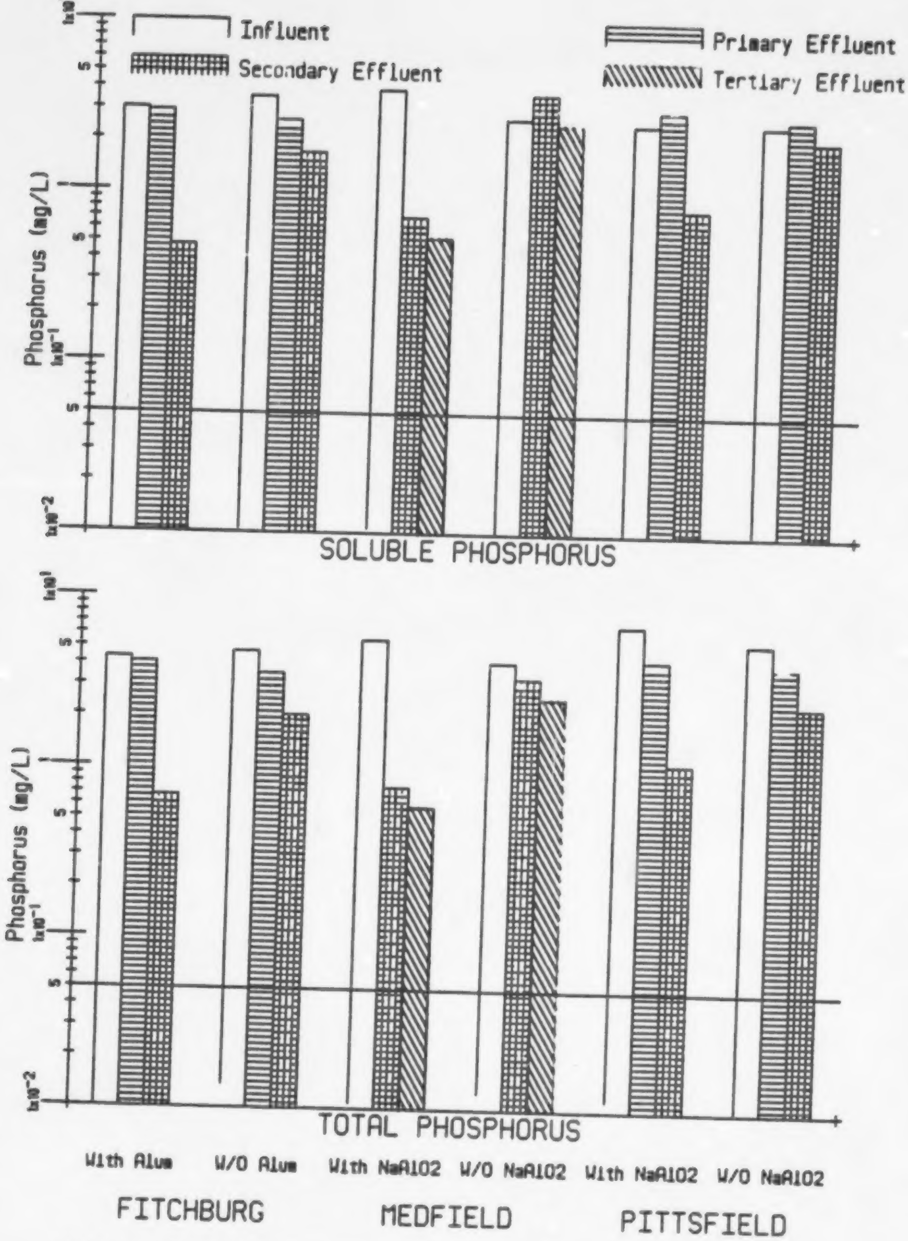


Figure 17: Mean Concentration of Phosphorus in POTWs

biochemical oxygen demand (BOD) for all three plants. In addition, volatile suspended solids (VSS) and turbidity (TURB) were used for the Fitchburg plant because data were available from the plant operators. The values for phosphorus and TOC were obtained from our analyses, but for the remaining parameters the values provided by the plant personnel were used (See Appendix D). Although some BOD and TSS analysis were done in our laboratory it was felt that the values provided by the plant personnel would be more accurate as the analyses were done on site without the time lag due to transporting the samples back to the laboratory which our samples encountered. Metal-parameter pairs which had a correlation coefficient greater than 0.5 are listed in Table 15. The remaining coefficients are in Appendix E.

Fitchburg

Selenium removal correlates with both BOD and turbidity removal at Fitchburg when alum is used. Without alum addition selenium removal appears to be related to phosphorus removal. Silver, copper, and mercury all correlate with both TOC and phosphorus removal. These metals show little correlation with these parameters when alum is used indicating that they may be removed by different mechanisms with and without the addition of alum. The same appears true for zinc removal and its relationship with TOC removal. There is a correlation between zinc and TSS removal which also holds without alum, but it is a weak correlation (coefficient=0.4). This relationship indicates that zinc is associated with the particulate phase.

Pittsfield

At Pittsfield the parameters which correlate with metals removal are BOD, TSS and phosphorus removal. Mercury, lead and zinc removals all correlate with TSS removal when sodium aluminate is used. All these metals are present primarily in the insoluble phase and the correlations indicate they were associated with the suspended solids which were removed. The selenium-BOD pair indicates that the selenium may be associated with the organic matter and/or removed by the same mechanism as BOD. The correlation of zinc and phosphorus removal could mean that they are removed by the same mechanism and, therefore, sodium aluminate may enhance zinc removal.

When sodium aluminate is not added, lead, zinc, and copper removal are associated with TSS removal. Copper removal also correlates with BOD removal, as do silver and mercury removals.

Medfield

For Medfield, there were very few pairs which had a significant correlation. The removal of cadmium, copper and lead appears to increase with increasing BOD removal indicating these metals may be associated with the organic matter in the wastewater stream. However, with only 3 data points for each pair, this cannot be stated with certainty. The removal of

TABLE 15

SIGNIFICANT CORRELATION COEFFICIENTS

PLANT	METAL	PARAMETER	N	CORR. COEFFICIENT
Fitchburg (with alum)	Se	BOD	14	0.6570
	Se	TURB	14	0.6209
Fitchburg (without alum)	Ag	P	20	0.8796
	Ag	TOC	20	0.9565
	Cu	P	27	0.8099
	Cu	TOC	27	0.8490
	Hg	P	18	0.6159
	Hg	TOC	18	0.7470
	Se	P	7	0.7894
	Zn	TOC	9	0.6270
	Zn	TSS	9	0.5449
Medfield (with sodium aluminate)	Cd	BOD	3	0.9339
	Cu	BOD	3	0.9973
	Pb	BOD	3	0.6873
	Se	P	11	0.7430
Medfield (without sodium aluminate)	Hg	TSS	15	0.6292
Pittsfield (with sodium aluminate)	Hg	TSS	7	0.6439
	Pb	TSS	8	0.6729
	Se	BOD	7	0.8981
	Zn	P	16	0.5183
	Zn	TSS	8	0.9278
Pittsfield (without sodium aluminate)	Ag	BOD	9	0.6730
	Cu	TSS	10	0.5513
	Cu	BOD	9	0.6164
	Hg	BOD	9	0.5485
	Pb	TSS	9	0.6012
	Zn	TSS	10	0.5296

selenium shows a strong correlation with phosphorus removal when sodium aluminate is used. The selenium may be removed by the same mechanism as the phosphorus. Mercury, which is mostly removed during primary sedimentation, correlates, as may be expected, with the removal of total suspended solids.

MASS BALANCES

An attempt was made to determine mass balances for several of the metals at the three treatment plants. By knowing the wastewater and the sludge flows and the metals concentrations within those streams, the mass of metal per day entering and leaving the plants can be determined. Unfortunately, flow data on recycle and supernatant streams are not available in most cases; so, assumptions must be made and precise balances are impossible.

Fitchburg and Medfield have complicated flow charts with many recycle streams (see Figures 2 & 4). There are no data available for any of these streams in terms of flow rates or metal concentrations. The sludge wasting at these plants is irregular, as it was required only 2-3 times a week. For these reasons, it is difficult to perform mass balances at these plants. Simplified mass balances were attempted but these yielded no consistent results. More data than available for our study are required to perform relevant mass balances at these plants.

Pittsfield has the simplest flow chart with a minimum of recycle lines (see Figure 3). The sludge is wasted daily to an anaerobic digestor. The concentrations of metals in this sludge are listed in Table 16 and the flow rates are given in Appendix D. A waste activated sludge stream is recycled back into the system when required. Because no data are available for the flow rate or the frequency of recycle, this stream has been ignored and this can introduce some error into the mass balances.

The flow rate of the digestor supernatant recycle stream is insignificant (about 1% of the wastewater influent flow rate) and, therefore, it was not included in the mass balances. However, because of the high concentrations of metals in this stream, it could contribute significantly to the metals concentrations in the primary treatment influent. Table 17 lists the supernatant metals concentrations, which are up to 2-3 orders of magnitude greater than the wastewater influent metals concentrations. The contribution by the supernatant stream is accounted for, as the influent sampling point is after the recycle stream entry point.

Mass balances were attempted for days on which sludge metals data were available and on metals which were present in the influent above the detection limit. It was assumed that the effluent flow rate was equal to the influent flow rate. The metals concentrations in the wastewater streams were averaged over a two day period (the day for which the sludge data were available and the preceeding day) to account for any time lag through the system. The results of the balances done on the Pittsfield plant are presented in Table 18. The values

TABLE 16

Concentration of Metals and Phosphorus in Sludge Samples

PLANT	C.DATE	Ag mg/L	Al mg/L	As mg/L	Be ug/L	Cd ug/L	Cr mg/L	Cu mg/L	Hg ug/L	Pb mg/L	Sb ug/L	Se mg/L	Tl ug/L	Zn mg/L	P mg/L
FIT	10 13 82	6.32	2215.7	2.60	17.23	233	34.67	86.4	94.0	116.99	2665	1.36	8.34	18.47	*****
	10 21 82	8.39	1356.2	2.06	13.98	464	29.52	71.5	110.0	72.97	2802	0.95	5.00	11.08	*****
	11 2 82	3.78	1609.0	2.33	26.99	362	37.92	99.1	105.0	15.74	5537	0.33	5.53	14.77	45.93
	12 10 82	1.76	1103.4	1.19	13.26	236	31.00	68.5	68.0	*****	1844	0.28	5.00	12.92	132.52
MED	10 4 82	1.88	1381.5	2.39	12.61	151	1.31	43.5	304.0	4.88	2391	1.08	5.53	14.77	19.11
	10 12 82	1.84	2409.0	3.81	12.95	222	1.34	48.5	228.0	2.89	3759	2.51	5.00	14.77	*****
	10 18 82	1.63	1204.5	2.80	12.27	108	1.36	34.3	287.0	4.22	1708	1.35	6.93	9.23	116.26
	10 25 82	2.00	2064.0	2.86	17.06	291	1.72	44.0	228.0	5.98	2255	0.20	13.95	18.47	80.89
	11 8 82	2.13	1735.4	2.63	16.21	392	4.04	44.0	350.0	5.32	5401	0.28	9.64	12.92	67.07
	11 17 82	2.09	1659.5	2.18	8.80	124	1.77	44.0	332.0	5.09	5125	0.78	5.00	12.92	48.37
	11 29 82	2.95	1912.3	1.67	7.76	254	1.71	50.1	383.0	7.29	1159	0.62	5.53	14.77	100.00
	12 10 82	1.13	875.9	1.61	7.27	392	1.51	36.0	255.0	9.49	1195	0.33	5.00	9.23	50.00
	12 15 82	1.15	875.9	1.46	6.12	423	1.69	47.0	238.0	5.09	785	0.28	5.00	11.08	63.01
PIT	9 22 82	2.79	1432.0	3.06	12.27	2255	5.39	71.3	101.0	9.06	3623	1.17	6.93	16.62	*****
	9 29 82	2.42	1204.5	2.83	12.95	1742	4.72	66.2	141.0	5.98	3075	1.36	9.74	22.17	135.77
	10 8 82	2.87	1406.7	2.68	14.67	2009	4.72	68.7	94.0	8.62	3075	1.22	6.93	16.62	79.27
	10 15 82	2.75	1988.2	2.68	13.64	1876	4.49	73.8	*****	8.62	1571	1.35	11.12	18.47	80.89
	10 25 82	2.46	1507.9	2.48	13.12	2098	6.97	62.3	127.0	7.14	1844	1.23	5.00	12.92	54.07
	10 29 82	4.11	1811.2	1.73	10.89	1965	7.63	59.3	118.0	5.54	1708	0.67	5.00	11.08	116.26
	11 8 82	2.13	1406.7	1.61	5.53	2276	4.72	40.9	105.0	5.32	1980	1.18	5.00	7.38	85.37
	11 12 82	2.05	1432.0	1.61	*****	1475	3.82	36.8	105.0	5.09	2937	0.45	5.19	9.23	39.43

TABLE 17

Concentration of Metals and Phosphorus in Supernatant Samples

PLANT	C.DATE	Ag mg/L	Al mg/L	As mg/L	Be ug/L	Cd ug/L	Cr mg/L	Cu mg/L	Hg ug/L	Pb mg/L	Sb ug/L	Se mg/L	Tl ug/L	Zn mg/L	P mg/L
PIT	10 5 82	1.90	1432.0	2.24	9.09	2032	4.01	56.20	76.00	9.50	4851	0.73	16.75	14.77	119.51
	11 2 82	1.21	825.3	2.15	9.09	1787	4.24	50.10	114.00	5.98	1571	0.78	5.53	11.08	24.80
	11 8 82	1.65	1078.1	2.15	8.50	1787	4.78	56.20	88.00	5.98	1469	0.50	5.53	11.08	36.99
	11 16 82	0.79	1507.9	2.06	7.91	1586	4.42	44.00	85.00	7.08	2802	0.73	6.93	14.77	42.68

REMARKS:

1. ***** indicates no analysis.
2. Tl detection limit 5.00 ug/L due to sludge samples being diluted five times when digested.
3. Ni does not appear in the table since all but two of the samples had Ni concentrations below the detection limit.

TABLE 18

RESULTS OF MASS BALANCES AT PITTSFIELD

(values in lbs/day)

DATE		As	Cd	Cr	Cu	Sb	Hg	Pb	Se
09 22 82	INFLUENT	1.734	1.182	3.566	29.175	1.454	0.086	5.490	3.039
	EFFLUENT	0.573	0.415	0.321	4.144	1.049	0.023	0.490	0.980
	SLUDGE	1.034	0.762	1.821	24.095	1.224	0.034	3.062	0.395
	%RECOVERY	92.7	99.6	60.1	96.8	156.0	66.3	64.7	45.2
09 29 82	INFLUENT	1.685	1.078	3.551	41.771	1.605	0.046	4.791	2.422
	EFFLUENT	0.442	0.340	0.249	4.394	0.885	0.015	0.485	1.849
	SLUDGE	1.011	0.622	1.686	23.642	1.098	0.050	2.136	0.486
	%RECOVERY	86.2	89.2	54.5	67.2	124.0	141.0	54.7	96.4
10 08 82	INFLUENT	0.913	1.135	4.578	42.431	0.989	0.026	7.451	0.890
	EFFLUENT	0.610	0.278	0.287	5.259	0.871	0.014	1.243	0.889
	SLUDGE	1.006	0.754	1.772	25.795	1.155	0.035	3.237	0.458
	%RECOVERY	177.0	90.9	45.0	73.2	205.0	188.0	60.1	151.0
10 15 82	INFLUENT	1.108	0.866	3.325	28.742	1.173		2.696	1.514
	EFFLUENT	0.365	0.114	0.449	6.113	0.729		0.365	1.005
	SLUDGE	0.991	0.693	1.660	27.279	0.581		3.186	0.499
	%RECOVERY	122.0	93.2	63.4	116.0	112.0		132.0	96.0
10 25 82	INFLUENT	1.376	1.033	4.950	38.117	1.493	0.041	11.031	1.191
	EFFLUENT	0.340	0.174	0.404	7.297	0.694	0.014	0.588	0.681
	SLUDGE	0.931	0.788	2.617	23.392	0.692	0.048	2.681	0.462
	%RECOVERY	92.4	93.1	61.0	80.5	92.8	152.0	29.6	96.0
10 29 82	INFLUENT	1.669	2.935	6.698	73.078	1.636	0.060	10.366	0.744
	EFFLUENT	0.408	0.274	0.581	7.451	1.236	0.014	0.393	0.684
	SLUDGE	0.693	0.787	3.056	23.750	0.684	0.047	2.219	0.268
	%RECOVERY	66.0	36.2	54.3	42.7	117.0	102.0	25.2	128.0
11 08 82	INFLUENT		1.122	3.481	43.615	1.316	0.053	6.054	0.682
	EFFLUENT		0.234	0.407	7.720	0.720	0.014	0.572	0.682
	SLUDGE		0.826	1.713	14.845	0.719	0.001	1.931	0.163
	%RECOVERY		94.5	60.9	51.7	109.0	98.1	41.3	124.0
11 12 82	INFLUENT	1.015	1.182	4.244	35.920	1.371	0.030		
	EFFLUENT	0.341	0.817	0.797	11.735	0.871	0.014		
	SLUDGE	0.584	0.535	1.387	13.357	1.066	0.038		
	%RECOVERY	91.1	114.0	51.5	69.9	141.0	173.0		

are expressed in pounds per day, and the percentage of metal in the influent which is accounted for in the effluent and the sludge has also been tabulated.

For arsenic, cadmium, copper and selenium, the average percentages of influent metals accounted for in the sludge and the effluent were 75-104%. The recovery percentages for lead and chromium were low, averaging 56-58%. The low recovery could be due to low concentrations of the two metals in the sludge samples or because of some component in the sludge which may interfere with the lead and chromium analyses. Unfortunately, matrix effects were not evaluated for the sludge sample so this cannot be confirmed. The mercury and antimony recoveries were high - around 130%. The high values for mercury and, partially, for antimony, may be attributed to the fact that the effluent concentrations measured were at or below the detection limit. As previously explained, all measurements that were less than the minimum detectable limit were reported as being at the detection limit. The true values are probably less than the those actually reported, but it is not possible to determine by how much. This method of reporting data makes it appear that more of these metals are leaving the plant than may actually be the case.

DISCUSSION OF RESULTS

Of the metals measured for this study, thallium, beryllium, and nickel were not found in detectable levels in the Fitchburg, Medfield, and Pittsfield, Massachusetts POTW influents. However, for beryllium and thallium measureable amounts could be found in the sludge, indicating that the treatment plants are removing these metals (see Table 16). A comparison of the concentrations of these metals in the sludge shows that generally the concentrations are greater during the period when aluminum salts are added, indicating that precipitant addition may enhance the removal of these two metals.

Small amounts of silver were found at all three treatment plants, mostly in the particulate phase. Little removal was achieved during primary sedimentation, but good removals were obtained overall (85-92% of total and 82-88% of soluble silver removed). These removals are near the upper limit of the range of removals found by Convery et al (1980) in normal activated sludge systems (see Table 5). However, they are slightly less than the 96.9% removal obtained by Hannah et al (1977) in laboratory tests with higher doses of alum. The removal when alum/aluminate was not present correlated with phosphorus removal and TOC removal at Fitchburg and with BOD removal at Pittsfield. However, because most of the effluent samples were at or below the detection limit even with no alum/aluminate addition, no comparison can be made of the extent of removal with and without aluminum salts.

There was little measurable arsenic in the Fitchburg or Medfield wastewaters and only a small amount in the Pittsfield influent. Because most of the influent concentration values were not much higher than the detection limit and most of the effluent concentrations were at the detection limit, the % removals calculated may not give the true picture. Essentially complete removal may be concluded. Therefore, no conclusions can be made about the effect of aluminum salts on arsenic removal.

There was a measurable amount of cadmium in the three wastewater influents of which 25-30% was in the soluble phase, similar to the phase distribution of spiked additions of metals in raw sewage studied by Patterson et al (1975). Primary sedimentation had little effect on the cadmium concentration although overall removals were good, ranging from 73 to 89% removal. The tertiary treatment at Medfield was effective at removing cadmium. The filtration process appeared to increase the cadmium concentration in many of the samples and this was confirmed by the quality control analyses on the filtration procedure. No statistically significant difference was observed in cadmium removal with and without the addition of aluminum salts.

Chromium was present primarily in the insoluble phase for the three plants. There was little or no removal during primary treatment and the majority of removal was in the activated sludge process (including final sedimentation). There was an increased removal when aluminum salts were added which is confirmed stastically in the case of Pittsfield where removal decreased from 76% to 58% when sodium aluminate addition was discontinued. Sodium aluminate appeared to be more efficient than alum for chromium removal; although, at the elevated doses used in laboratory studies by Hannah et al (1977), 97% of Cr(III) was removed by alum coagulation.

Copper was present in significant amounts in the treatment plant influents. The total concentrations were about five times the soluble concentrations. Primary treatment had little effect on the copper. Correlations show that when alum/aluminate was not added copper removal was related to phosphorus and TOC removal at Fitchburg and to BOD and TSS removal at Pittsfield. When sodium aluminate was added at Medfield the removal of copper correlated with BOD removal. Mean overall removals of 88-92.5% were achieved during aluminum salt addition and these dropped to 76-87% when the addition was discontinued. The overall copper removals obtained during aluminum salt addition are also higher than those found previously in activated sludge systems (see Table 5). The t-tests confirm that the use of aluminum salts increased copper removal at Pittsfield and Fitchburg. There also appeared to be a slight improvement at Medfield when sodium aluminate was used.

There is little measurable soluble mercury entering any of the treatment plants. Fitchburg also had very little particulate mercury. At all the three treatment plants the mercury present was removed to the lowest detection limit by primary treatment which occurs before the addition of aluminum salts. Therefore, no conclusions can be made about the effect of aluminum salts on mercury removal.

Lead was found in significant concentrations in all the treatment plants, especially at Fitchburg. The soluble lead concentration was less than 10% of the total lead concentration. Patterson et al (1975) found an even smaller percentage of soluble lead (1.3%) when they spiked raw sewage with lead. Only a small amount of lead was removed by primary sedimentation at Fitchburg. However, more lead was removed through primary treatment at Pittsfield where there appeared to be a relationship between lead removal and total suspended solids removal. Higher overall removals were observed when aluminum salts were used, 69-91% compared to 26-81% when aluminum salts were not used, but because of the large variance in the data this cannot be confirmed by the t-tests.

There was a small amount of antimony present in all the influents. There appeared to be some component which was removed to some extent during primary treatment and during the laboratory filtration process which interfered with the antimony analysis, as explained earlier. Therefore many values may be higher than are reported. From the data available, the removal of antimony was poor, averaging from 3-39% overall. This was, however, comparable with the 0-34% removal observed by Convery et al. (1980) in standard activated sludge plants. There was no difference in removal efficiency with and without the aluminum salt addition.

Selenium was present in small concentrations at Pittsfield, but few detectable values were found at Fitchburg or Medfield. Primary treatment removed a significant percentage of the selenium removed at Pittsfield (27-44% primary removal when overall removals were 39-71 %). As with arsenic, most of the effluent values were at or below the detection limit without the precipitant addition, so the effect of aluminum salt addition cannot be determined.

No soluble zinc was found above the detection limit in any of the treatment plant influents. Many of the total zinc concentration values were at the detection limit for Medfield and Fitchburg, but they were consistently above the detection limit for the Pittsfield influents. Some removal was achieved during primary treatment, whereas secondary treatment removed the remaining zinc to below the detctable limit. The correlation data indicates that the overall removal of zinc was related to total suspended solids removal. Also, since all the effluent values were at the detection limit without the aluminum salt addition, no evaluation of the effect of alum/aluminate on zinc removal can be made.

Aluminum is not a metal on the list of priority pollutants. However, analysis was made for aluminum to insure that the addition of aluminum salts did not cause an increase in the aluminum concentration in the discharge. Overall, the net decrease in the influent aluminum was 58% at Fitchburg and greater than 90% at Medfield and Pittsfield, both during the aluminum salt addition and after its discontinuation. Conventional treatment processes are capable, therefore, of removing aluminum in concentrations much greater than those normally encountered in wastewater.

As a guideline for the effectiveness of the POTW in producing an effluent containing acceptably low concentrations of heavy metals, the mean values of the final effluent metals concentrations are compared with the drinking water standards limits (Code of Federal Regulations) in Tables 19, 20, and 21. This is not to imply that the treated sewage effluents must meet drinking water standards. On the other hand, if they do meet these standards, they should have no adverse impact on the environment.

The only final effluent metal concentration significantly above the drinking water standards was the lead content in the Fitchburg effluent. The total lead concentration exceeded the recommended limit of 50 ug/L, although the soluble portion was within the recommended limits. The addition of alum at Fitchburg reduced the total lead concentration from 150 to 78 ug/L, a reduction of approximately 50%. Although the final effluent total lead concentration still exceeded the drinking water standards, the alum did effect a significant and worthwhile reduction in the lead concentration.

There were also several instances in which the selenium concentration in the final effluent apparently exceeded the drinking water standard of 10 ug/L. It must be pointed out that the minimum detection limit for selenium was 10 ug/L, and that any values possibly less than this were always recorded as being equal to the detection limit. Therefore, a true mean might actually be some lower, although uncalculable, value. Thus the only instance in which the selenium content in the effluent statistically exceeded the drinking water standard was the 16.8 ug/L total Se content in the effluent from Pittsfield during the period of addition of sodium aluminate. This value was slightly greater than that without the sodium aluminate.

Total organic carbon (TOC) was present at concentrations from 10 to 200 mg/L in the raw wastewater at the three treatment plants. There was little removal during primary sedimentation, but overall removal by secondary treatment was about 80%. Generally the removal of total TOC was greater than soluble TOC removal. There was no significant difference in TOC removal when aluminum salts were added.

Soluble phosphorus accounted for about two-thirds of the total phosphorus present at Fitchburg and Medfield and a little less than half of the total at Pittsfield. The majority of removal occured during secondary treatment. Little removal of phosphorus was achieved during primary or tertiary treatment. As expected, the addition of the aluminum salts significantly decreased the concentration of phosphorus in the discharge. Concentrations averaged from 0.59 to 1.09 mg P/L in the effluent stream during precipitant addition and from 2.03 to 2.59 mg P/L after the addition was discontinued. The concentration of 1.09 mg/L in the discharge at Pittsfield during aluminate addition may not represent the true picture. A close look at the daily concentrations (see Appendix A) shows a steady increase in phosphorus concentration in the final effluent during the the last week that sodium aluminate was added. Discussion with the treatment plant personnel indicated that a less than optimum dosage of sodium aluminate may have been applied on these days because the supply was low and they did not want to purchase a new large supply at the end of the season. If these days are not included, the mean final

Table 19

Comparison of Mean Metals Concentrations in the Final Discharge With Drinking Water Standards

Fitchburg POTW

Metal	Water Standard	Effluent Concentration			
		Without Alum		With Alum	
		Soluble	Total	Soluble	Total
Aluminum	None	93.3	533.8	89.6	652.8
Antimony	None	12.36	12.36	11.11	11.58
Arsenic	50[1]	5.63	7.51	5.24	5.73
Beryllium	None	<0.5	< 0.5	<0.5	< 0.5
Cadmium	10[1]	2.04	0.92	2.09	0.57
Chromium	50[1]	3.2	18.6	3.0	17.3
Copper	1,000[2]	22.2	65.5	20.5	42.3
Lead	50[1]	15.2	150.0	30.2	78.2
Mercury	2[1]	0.20	0.22	0.20	0.20
Nickel	None	<1,000	< 1,000	<1,000	<1,000
Selenium	10[1]	10.00	10.16	10.00	10.83
Silver	50[1]	2.00	2.46	2.00	2.00
Thallium	None	<5	< 5	<5	< 5
Zinc	5,000[2]	300	300	300	300

All Values as μg/L

---

[1] Maximum limit (CFR 40 Part 141.11)

[2] Recommended limit (CFR 40 Part 143.3)

TABLE 20

Comparison of Mean Metals Concentrations in the Final Discharge With Drinking Water Standards

Pittsfield POTW

Metal	Water Standard	Effluent Concentration			
		Without Alum		With Alum	
		Soluble	Total	Soluble	Total
Aluminum	None	117.8	1,024.9	160.1	1,032.1
Antimony	None	13.47	13.05	14.62	11.45
Arsenic	50[1]	5.24	7.91	5.47	7.39
Beryllium	None	<0.5	<0.5	<0.5	<0.5
Cadmium	10[1]	4.04	4.23	4.34	4.10
Chromium	50[1]	4.0	7.0	3.1	3.8
Copper	1,000[2]	73.8	102.4	52.5	57.9
Lead	50[1]	6.5	28.3	5.0	5.9
Mercury	2[1]	0.21	0.23	0.30	0.23
Nickel	None	<1,000	<1,000	<1,000	<1,000
Selenium	10[1]	10.00	10.65	10.28	16.81
Silver	50[1]	2.00	2.57	2.00	2.00
Thallium	None	<5	<5	<5	<5
Zinc	5,000[2]	300	300	300	300

All Values as µg/L

---

[1] Maximum limit (CFR 40 Part 141.11)

[2] Recommended limit (CFR 40 Part 143.3)

TABLE 21

Comparison of Mean Metals Concentrations in the Final Discharge With Drinking Water Standards

Medfield POTW

Metal	Water Standard	Effluent Concentration			
		Without Alum		With Alum	
		Soluble	Total	Soluble	Total
Aluminum	None	68.8	73.3	86.4	97.4
Antimony	None	12.91	12.73	11.83	12.39
Arsenic	50[1]	5.15	6.21	5.14	5.99
Beryllium	None	<0.5	<0.5	<0.5	<0.5
Cadmium	10[1]	1.64	0.50	2.07	0.80
Chromium	50[1]	3.0	5.2	3.0	3.3
Copper	1,000[2]	12.8	17.1	13.5	19.1
Lead	50[1]	10.4	9.3	6.4	9.0
Mercury	2[1]	0.20	0.20	0.23	0.20
Nickel	None	<1,000	<1,000	<1,000	<1,000
Selenium	10[1]	10.05	10.00	10.00	12.11
Silver	50[1]	2.00	2.00	2.00	2.00
Thallium	None	<5	< 5	<5	<5
Zinc	5,000[2]	300	300	300	300

All Values as μg/L

[1] Maximum limit (CFR 40 Part 141.11)

[2] Recommended limit (CFR 40 Part 143.3)

effluent concentration would be consitently less than 1 mg/L, and the overall phosphorus removal when sodium aluminate was used would be higher.

REFERENCES

1. Allen,H.E., Hall,R.H. and Brisban,T.D., "Metal Speciation: Effects on Aquatic Toxicity." Environmental Science and Technology, 14:4, 441 (1980).

2. APHA-AWWA-WPCF, "Standard Methods for the Examination of Water and Wastewater, 15th Edition." (1981).

3. Bailey,S.M., Helz,G.R. and Harris,R.L., "Investigation of the Transport of Metals and Orthophosphates Away from a Sewage Treatment Plant Outfall." Environmental Letters, 10:2, 159 (1973).

4. Barth,E.F., English,J.N. and Salotto,B.V., "Field Survey of Four Municipal Wastewater Treatment Plants Receiving Metallic Wastes." Journal of the Water Pollution Control Federation, 37, 1101 (1965).

5. Batley,G.E. and Gardner,D., "Sampling and Storage of Natural Waters for Trace Metal Analysis" Water Research, 11:9, 745 (1977).

6. Bowen,H.J.M., "Trace Elements in Biochemistry." Academic Press, New York (1966).

7. Brown,H.G., Hensley,C.P., McKinney,G.L. and Robinson,J.L., "Efficiency of Heavy Metal Removal in Municipal Sewage Treatment." Environmental Letters, 5,2 (1973).

8. Bruland,K.W., Bertine,K., Koide,M. and Goldberg,E.D., "History of Metal Pollution in Southern California Coastal Zone." Environmental Science and Technology, 8, 425 (1974).

9. Carrondo,M.J.T., Lester,J.N. and Perry.R., "Type A Zeolite in Activated Sludge Process-II: Heavy Metal Removal." Journal of the Water Pollution Control Federation, 53:3, 344 (1981).

10. Chau,Y.K., "Complexing Capacity of Natural Water: Its Significance and Measurement."Journal of Chromatographic Science,11, 579 (1973)

11. Chen,K.Y., Young,C.S., Jan,T.K. and Rohatgi,N., "Suspended and Dissolved Trace Elements in Wastewater Effluents." Presented at the 46th Annual Confernece of the Water Pollution Control Federation, (1973).

12. Cheng,M.H., Patterson,J.W. and Minear,R.A.,"Heavy Metal Uptake by Activated Sludge" Presented at the 46th Annual Conference of the Water Control Federation, (1973).

13. Code of Federal Regulations, 40, Revised as to July 1, 1982.

14. Convery,J.J., Cohen,J.M. and Bishop,D.F.,"Occurence and Removal of Toxixs in Municipal Wastewater Treatment Facilities." Presented at the 7th Joint United States/Japan Conference, (1980).

15. Cox,J.A., Lundquist,G.L., Webster,R.G., Cox,R.A., Lindahl,P.C. and Caskey,A.C.,"The Sources and Levels of Mercury in the Sewage of a University Campus."Bulletin of Environmental Contamination and Toxicology,13, 397 (1975).

16. David,M.H., Schroeder,F.J., Pierce,J.J., Joeres,E.F. and Braasch,D.A.,"Statistical Study of Phosphorus Removal in Wisconsin." Journal of the Environmental Engineering Division, American Society of Civil Engineers,102, 433 (1976).

17. Davis,J.A. and Jacknow,J.,"Heavy Metals in Wastewater in Three Urban Areas." Journal of the Water Pollution Control Federation,47, 2292 (1975).

18. EPA,"Methods for Chemical Analysis of Water and Wastes."Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S.Environmental Protection Agency, Cincinnati, Ohio (1979).

19. Esmond,S.E. and Petrasek,A.C., "Trace Metal Removal." Industrial Wastes Engineering,May, 1974.

20. Evans,R.L., Sullivan,W.T. and Lin,S.,"Mercury in Public

Sewer Systems." Water and Sewage Works, 120:2, 75 (1973).

21. Gardiner, J., "The Chemistry of Cadmium in Natural Water, I: A Study of Cadmium Complex Formation Using the Cadmium Specific Ion Electrode." Water Research, 8, 23 (1974).

22. Gelman, Personal Communication

23. Gibbs, R.J., "Mechanisms of Trace Metal Removal." Science, 180, 71 (1973).

24. Haas, C.N., "Soluble Phase Chemistry of Trace Metal Transport in Secondary Wastewater Treatment Systems." Masters Thesis, Illinois Institute of Technology, (1974).

25. Hahne, H.C.H. and Kroontje, W., "Significance of pH and Chloride Concentration on the Behavior of Heavy Metal Pollutants: Mercury(II), Cadmium(II), Zinc(II) and Lead(II)." Journal of Environmental Quality, 2, 444 (1973).

26. Handbook for Monitoring Industrial Wastewater. U.S. Environmental Protection Agency, Technology Transfer (1973).

27. Hannah, S.A., Jelus, M and Cohen, J.M., "Removal of Uncommon Trace Metals by Physical and Chemical Treatment Processes." Journal of the Water Pollution Control Federation, 49, 2297 (1977).

28. Hannah, S.A., Personal Communication

29. Humenick, M.J. and Schnoor, J.L., "Improving Mercury(II) Removal by Activated Carbon." Journal of the Environmental Engineering Division, American Society of Civil Engineers, 100, 1249 (1974).

30. Jenkins, S.H., Keight, D.G. and Ewins, A., "The Solubility of Heavy Metal Hydroxides in Water, Sewage and Sewage Sludge, II: The Precipitation of Metals by Sewage." Int. Journal of Air and Water Pollution, 8, 679 (1964).

31. Jennett, J.C. and Wixson, B.G., "Industrial Treatment of Heavy Metals to Protect Aquatic Systems in the Lead Belt Area." Presented at the 30th Annual Purdue Industrial Waste

Conference, (1975).

32. Keough, E.B., "Soluble Metal Concentrations in a Secondary Waste Treatment Plant Using Alum." Master's Thesis, Rensselaer Polytechnic Institute, (1978).

33. Kinniburgh,D.G., Sridhar,K. and Jackson,M.L.,"Specific Adsorption of Zinc and Cadmium by Iron and Aluminum Hydrous Oxides." ERDA Symposium Series 42, "Biological Implications of Metals in the Environment.", pp. 231-239 (1977).

34. Klein,L.A., Lang,M., Nash,N. and Kirshner,S.,"Sources of Metals in New York City Wastewater." Journal of the Water Pollution Control Federation,46, 12 (1974).

35. Konrad,J.G. and Kleinert,S.J.,"Surveys of Toxic Metals in Wisconsin: Removal of Metals from Wastewaters by Municipal Sewage Treatment Plants." Tech. Bull.,74, Department of Natural Resources, State of Wisconsin, (1974).

36. Laxen,D. and Harrison,R.,"The Physiochemical Speciation of Cd, Pb, Cu, Fe and Mn in the Final Effluent of a Sewage Treatment Works."Water Research,15:9, 1053 (1981).

37. Leckie,J.O., Davis,J.A. and Benjamin,M.M., "Adsorption/Desorption of Heavy Metals at Hydrous Oxide Interfaces: Influence of Solution and Solid Characteristics." ACS Division of Environmental Chemistry, Preprints of Papers Presented at the 175th Annual Meeting,18, 56 (1978).

38. Legendre,G.R. and Runnels,D.D.,"Removal of Dissolved Molydenum from Wastewater by Precipitates of Ferric Iron."Environmental Science and Technology,9, 744 (1975).

39. Lehman,G.S. and Wilson,L.G.,"Trace Element Removal From Sewage Effluent by Soil Filtration." Water Resource Research,7:1, 90 (1971).

40. Lewandowski,G.A. and Abd-El-Bary,M.F.,"Sludge Appliication: Remove Heavy Metals Two Ways." Water and Sewage Works127:1, 44 (1980).

41. Lindstedt,K.D., Bennett,E.R., Fox,R.L. and Heaton,R.D.,"Alum Clarification for Improving Wastewater

Effluent Quality." Water Research,8, 753 (1974).

42. Logsdon,G.S. and Symons,J.M.,"Mercury Removal by Conventional Water Treatment Techniques." Journal of the American Water Works Association, 65:8, 554 (1973).

43. Maruyama,T., Hannah,S.A. and Cohen,J.M.,"Metal Removal by Physical and Chemical Treatment Processes." Journal of the Water Pollution Control Federation, 47, 962 (1975).

44. McGinness,J.A. and Harriger,R.D.,"Alum Tops Off Treatment." Water and Wastes Engineering,March, 1973, p.35.

45. Miller,I. and Freund,J.,"Probabilty and Statistics for Engineers." Prentice-Hall Mathmatical Series.

46. Minear,R.A., Ball,R.O. and Church,R.L.,"Data Base for Influent Heavy Metals in Publicly Owned Treatment Works." EPA Project Summary, (1981).

47. Morel,F.M.M., Westall,J.C., O'Melia,C.R. and Morgan,J.J.,"Fate of Trace Metals in Los Angeles County Wastewater Discharge." Environmental Science and Technology, 9, 756 (1975).

48. National Academy of Science. "Drinking Water and Health." Washington, D.C. (1971).

49. Nelson,P.O., Chung,A.K. and Hudson,M.C.,"Factors Affecting the Fate of Heavy Metals in the Activated Sludge Processes." Journal of the Water Pollultion Control Federation,53:8, 1323 (1981).

50. Netzer,A. and Wilkinson,P., "Removal of Heavy Metals from Wastewater by Adsorption on Sand." Presented at the 29th Annual Purdue Industrial Waste Conference. (1974).

51. Neufeld,R.D., Gutierrez,J. and Novak,R.A.,"A Kinetic Model and Equilibrium Relationship for Heavy Metal Accumulation." Journal of the Water Pollution Control Federation,49:3, 489 (1977).

52. Neufeld,R.D. and Hermann,E.R.,"Process Design Modifications for Activated Sludge Removal of Certain Heavy Metals."

Presented at the 46th Annual Water Pollution Control Federation Meeting. (1973).

53. Nilsson,R.,"Removal of Metals Treatment of Municipal Wastewater." *Water Research,*5, 51 (1971).

54. Ockershausen,R.W., "Wastewater Treatment for Phosphorus Removal." *Water and Sewage Works,*127:8, 40 (1980).

55. Oliver,B.G. and Cosgrove,E.G.,"The Efficiency of Heavy Metal Removal by a Conventional Activated Sludge Plant." *Water Research,*8, 659 (1974).

56. Ongerth,J.E. and Dewalle,F.B.,"Pretreatment of Industrial Discharges to POTWs." *Journal of the Water Pollution Control Federation,*52:8, 2247 (1980).

57. Patterson,J.W., Shimada,P. and Haas,C.N.,"Heavy Metal Transport Through Municipal Sewage Treatment Plants." Proceedings of the 2nd National Conference on Complete Water Reuse. (1975).

58. Perkin-Elmer (Norwalk, Connecticut),"Analytical Methods for Atomic Absorption Spectrophotometry." (1971).

59. Perkin-Elmer, Personal Communication

60. Pitt,R.E. and Amy,G.,"Toxic Materials Analysis of Street Surface Contaminants." Environmental Protection Technical Service, Washington,D.C. (1973)

61. Porcella,D.B. and McGauhey,P.H.,"Before Removing Nutrients, Reanalyze Lake Tahoe." *Water and Wastes Engineering,*13, 17 (1976).

62. Rebhun,M. and Streit,S.,"Physico-Chemical Treatment of Strong Municipal Wastewater." *Water Research,*8, 195 (1974).

63. Rossin,A.C., Steritt,R.M. and Lester,J.N.,"The Influence of Process Parameters on the Removal of Heavy Metals in Activated Sludge." *Water, Air, and Soil Pollution,*17:2, 185 (1982).

64. Sterritt,R.M., Brown,M.J. and Lester,J.N.,"Metal Removal by Adsorption and Precipitation in the Activated Sludge Process." Environmental Pollution Series A, 24:4, 313 (1981).

65. Sterritt,R.M. and Lester,J.N.,"The Influence of Sludge Age on Heavy Metal Removal in the Activated Sludge Process." Water Research, 15:1, 59 (1981).

66. Stoveland,S., Perry,R. and Lester,J.N.,"The Influence of Nitriloacetic Acid on Heavy Metal Transfer." Water Research, 13:11, 1043 (1979).

67. Sverdrup and Parcel Associates, "Draft Study of Selected Pollutant Parameters in Publicly Owned Treatment Works." Report to the U.S. Environmental Protection Agency. Contract 68-01-3289 (1977).

68. Sylva,R.N.,"The Environmental Chemistry of Copper(II) in Aquatic Systems." Water Research, 10, 789 (1976).

69. Truitt,R.E. and Weber,J.H.,"Influence of Fulvic Acid on the Removal of Trace Concentrations of Cd(II), Cu(II), and Zn(II) from Water by Alum Coagulation." Water Research, 13:12, 1171 (1979).

70. Yost,K.J., Wukasch,R.F., Adams,T.G. and Michalczyk,B.,"Heavy Metal Sources and Flows in a Municipal Sewage: Literature Survey and Field Investigation of the Kokomo, Indiana Sewage System." EPA Project Summary (1981).

71. Zemansky,G.M.,"Removal of Trace Metals During Conventional Water Treatment." Journal of the American Water Works Association, 66, 606 (1974).

APPENDIX A : Daily Concentrations

RESULTS OF SILVER ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM FITCHBURG TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 5 82	18.81	13.58	2.00	11.73	2.00	2.00
10 6 82	109.92	41.58	2.00	21.84	2.00	2.00
10 7 82	78.70	36.58	2.00	23.95	11.60	2.00
10 8 82	33.91	31.08	2.00	19.59	10.66	
10 13 82	13.11	2.00	2.00	2.00	2.00	2.00
10 14 82	26.11	18.08	2.00	2.00	2.00	2.00
10 15 82	31.47	18.58	2.00	19.59	11.92	2.00
10 16 82	44.09	12.33	2.00	16.49	2.00	2.00
10 17 82	2.00	2.00	2.00	2.00	2.00	2.00
10 18 82	2.00	2.00	2.00	2.00	2.00	2.00
10 19 82	21.52	19.43	2.00	23.62		2.00
10 20 82	37.59	36.83	2.00	2.00	2.00	
10 21 82	18.14		2.00	2.00		2.00
10 22 82	42.56		2.00	2.00		2.00
10 23 82	2.00		2.00	2.00		2.00
10 24 82	40.89		2.00	2.00		2.00
10 25 82	14.53		2.00	2.00		2.00
10 26 82	17.86		2.00	2.00		2.00
10 27 82	27.29		2.00	2.00		2.00
10 28 82	28.96		2.00	13.80		2.00
10 29 82	25.35		2.00	2.00		2.00
10 30 82	41.50		2.00	2.00		2.00
10 31 82	2.00		2.00	15.55		2.00
11 1 82	10.75		2.00	2.00		2.00
11 2 82	43.96		2.00	2.00		2.00
11 3 82	63.98		2.00	2.00		2.00
11 4 82			2.00			2.00
11 5 82	58.00		2.00	2.00		2.00
11 6 82	33.30		2.00	2.00		2.00
11 7 82	22.23		2.00	2.00		2.00
11 8 82	2.00		2.00	2.00		2.00
11 9 82	24.59		2.00	2.00		2.00
11 10 82	17.27		2.00	2.00		2.00
11 11 82	27.37		2.00	2.00		2.00
11 12 82	30.15		2.00	2.00		2.00
11 13 82	21.06		2.00	2.00		2.00
11 14 82	2.00		2.00	2.00		2.00
11 15 82	14.74		2.00	2.00		2.00
11 16 82	2.00		2.00	2.00		2.00
11 17 82	11.71		2.00	2.00		2.00
11 18 82	25.60		2.00	2.00		2.00
11 19 82	31.09		2.00	2.00		2.00
11 20 82	38.54	21.92	2.00	2.00	2.00	2.00
11 21 82	32.58	2.00	2.00	2.00	2.00	2.00
11 22 82	2.00	2.00	2.00	2.00	2.00	2.00
11 27 82	2.00	10.48	2.00	2.00	2.00	2.00
11 28 82	2.00		2.00	2.00		2.00
11 29 82	2.00		2.00	2.00		2.00
11 30 82	28.11	46.10	14.98	11.32	2.00	2.00
12 1 82	25.87	26.25	2.00	17.95	2.00	2.00
12 2 82	38.54	25.04	2.00	2.00	2.00	2.00
12 3 82	29.60		2.00	11.49		2.00

RESULTS OF SILVER ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM PITTSFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
9 17 82	23.31		2.00	11.50		2.00
9 20 82	10.33		2.00	2.00		2.00
9 21 82	15.89		2.00	2.00		2.00
9 22 82	2.00		2.00	2.00		2.00
9 23 82	14.31		2.00	2.00		2.00
9 24 82	29.11		2.00	10.09		2.00
9 27 82	22.78		2.00	2.00		2.00
9 28 82	28.61		2.00	10.56		2.00
9 29 82	29.41		2.00	13.61		2.00
9 30 82	24.64		2.00	10.09		2.00
10 1 82	10.86		2.00	2.00		2.00
10 4 82	24.11		2.00	2.00		2.00
10 5 82	27.29		2.00	2.00		2.00
10 6 82	27.55		2.00	2.00		2.00
10 7 82	23.05		2.00	15.49		2.00
10 8 82	28.35	10.58	2.00	10.09	2.00	2.00
10 12 82	2.00	2.00	2.00	2.00	2.00	2.00
10 13 82	31.85	12.33	2.00	2.00	2.00	2.00
10 14 82	29.94	13.58	2.00	13.54	2.00	2.00
10 15 82	23.82	2.00	2.00	2.00	2.00	2.00
10 18 82	15.02	2.00	14.58	2.00	2.00	2.00
10 19 82	26.88	16.24	2.00	2.00	2.00	2.00
10 20 82	30.70	21.56	2.00	2.00	2.00	2.00
10 21 82		28.31	2.00	5.17	2.00	2.00
10 22 82	47.53	21.21	2.00	2.00	2.00	2.00
10 25 82	15.36		2.00	2.00	2.00	2.00
10 26 82	27.57	29.45	2.00	2.00	2.00	2.00
10 27 82	34.23	25.47	2.00	2.00	2.00	2.00
10 28 82	33.95	21.21	2.00	16.40	2.00	2.00
10 29 82	89.00	24.05	2.00	18.20	2.00	2.00
11 1 82	2.00	2.00	2.00	15.35	2.00	2.00
11 2 82	47.24	14.82	2.00	2.00	2.00	2.00
11 3 82	41.50	27.24	2.00	2.00	2.00	2.00
11 4 82	32.48	14.11	2.00	2.00	2.00	2.00
11 5 82	48.47	11.98	2.00	2.00	2.00	2.00
11 8 82	14.85	2.00	2.00	2.00	2.00	2.00
11 9 82	40.27	11.84	2.00	2.00	11.71	2.00
11 10 82	35.76	2.00	2.00	2.00	2.00	2.00
11 12 82	23.33	10.75	2.00	2.00	2.00	2.00
11 15 82	11.46	2.00	2.00	2.00	2.00	2.00

RESULTS OF SILVER ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM MEDFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 4 82			2.00			2.00
10 5 82	2.00		2.00	2.00		2.00
10 6 82	2.00		2.00	2.00		2.00
10 7 82	12.98		2.00	2.00		2.00
10 8 82	2.00		2.00	2.00		2.00
10 12 82	2.00		2.00	2.00		2.00
10 13 82			2.00			2.00
10 14 82	2.00		2.00	2.00		2.00
10 15 82	2.00		2.00	2.00		2.00
10 18 82	2.00		2.00	2.00		2.00
10 19 82	2.00		2.00	2.00		2.00
10 20 82	11.58		2.00	2.00		2.00
10 21 82	2.00		2.00	2.00		2.00
10 22 82	12.59		2.00	2.00		2.00
10 25 82	15.08			2.00		
10 26 82	10.92		2.00	2.00		
10 27 82	2.00		2.00	2.00		2.00
10 28 82	2.00		2.00	2.00		2.00
10 29 82	36.17		2.00	2.00		2.00
11 1 82	2.00		2.00	2.00		2.00
11 2 82	14.03		2.00	2.00		2.00
11 3 82			2.00	2.00		2.00
11 4 82		2.00			2.00	
11 5 82	25.92	2.00	2.00	14.75	2.00	2.00
11 9 82	11.21	2.00		21.55	2.00	
11 10 82	19.79	2.00		2.00	2.00	
11 11 82	65.97	2.00	2.00	2.00	2.00	2.00
11 12 82	22.82	2.00	2.00	2.00	2.00	2.00
11 15 82	2.00	2.00	2.00	2.00	2.00	2.00
11 16 82	2.00	2.00	2.00	2.00	2.00	2.00
11 17 82	2.00	2.00	2.00	2.00	2.00	2.00
11 18 82	2.00	2.00	2.00	2.00	2.00	2.00
11 19 82	11.21	2.00	2.00	2.00	2.00	2.00
11 23 82	2.00	2.00	2.00	2.00	2.00	2.00
11 29 82	2.00	2.00	2.00	2.00	2.00	2.00
11 30 82	10.23	2.00	2.00	2.00	2.00	2.00
12 1 82	2.00	2.00	2.00	2.00	2.00	2.00
12 2 82	10.23	2.00	2.00	2.00	2.00	2.00
12 3 82		2.00	2.00		2.00	2.00
12 6 82	10.23	2.00	2.00	2.00	2.00	2.00
12 7 82	2.00	2.00	2.00	2.00	2.00	2.00
12 8 82	21.40	2.00	2.00	2.00	2.00	2.00
12 9 82	2.00	2.00	2.00	2.00	2.00	2.00
12 10 82		2.00			2.00	
12 13 82	28.08	2.00	2.00	12.17	2.00	2.00
12 14 82	2.00	2.00	2.00	2.00	2.00	2.00
12 15 82		2.00	2.00		2.00	2.00

RESULTS OF ARSENIC ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM FITCHBURG TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 5 82	5.00	6.16	5.52	5.00	5.00	5.00
10 6 82	5.00	8.51	5.00	5.00	5.00	5.00
10 7 82	10.68	5.97	5.91	5.00	5.00	5.00
10 8 82	9.55	10.42	5.00	6.77	5.00	
10 13 82	5.00	5.00	5.00	5.00	5.00	5.67
10 14 82	9.55	5.00	7.04	6.77	5.00	6.83
10 15 82	5.03	8.19	5.00	5.00	5.00	5.00
10 16 82	9.55	8.19	5.00	5.00	5.00	5.00
10 17 82	5.00	10.42	5.10	6.77	5.00	5.00
10 18 82	5.03	5.00	5.00	5.00	5.00	6.83
10 19 82	5.03	8.19	7.04	5.00		5.00
10 20 82	5.00	11.53	5.00	5.00	5.00	
10 21 82	5.24		5.00			5.00
10 22 82	13.62		5.00	5.29		5.00
10 23 82	8.24		5.00	5.00		5.00
10 24 82	5.62		5.00	5.00		5.00
10 25 82	5.24		5.00	5.29		5.00
10 26 82	8.83		5.00	5.00		5.95
10 27 82	5.00		5.00	5.00		5.00
10 28 82	12.42		5.00	11.27		5.00
10 29 82	7.77		8.98	7.28		5.00
10 30 82	5.00		9.41	5.00		5.00
10 31 82	5.00		7.24	5.00		5.00
11 1 82	7.77		6.16	7.39		5.00
11 2 82	9.04		16.99	5.41		5.00
11 3 82	16.63		16.99	5.00		5.28
11 4 82			16.99			5.00
11 5 82	7.77		10.49	9.36		5.00
11 6 82	5.62		15.90	5.00		5.00
11 7 82	6.50		5.00	5.00		5.00
11 8 82	5.00		5.00	5.00		5.28
11 9 82	7.08		5.00	7.39		5.00
11 10 82	5.00		5.00	5.41		5.00
11 11 82	12.01		5.00	7.33		5.00
11 12 82	12.01		5.00	10.88		5.00
11 13 82	8.31		5.00	9.11		5.00
11 14 82	5.00		5.00	5.00		5.00
11 15 82	5.85		5.00	5.56		5.00
11 16 82	5.00		5.00	5.00		5.68
11 17 82	5.85		8.46	5.00		8.95
11 18 82	5.85		15.95	7.33		11.14
11 19 82	5.85		8.40	10.88		7.86
11 20 82	12.03	15.91	5.00	12.65	5.00	5.00
11 21 82	7.34	8.31	5.00	7.33	6.43	5.00
11 22 82	6.59	5.00	5.00	5.00	5.32	6.77
11 27 82	8.24	5.77	5.00	5.00	5.00	6.77
11 28 82	8.51		5.00	5.00		5.00
11 29 82	5.00		5.00	5.00		5.00
11 30 82	6.16	5.00	5.10	6.05	5.00	5.00
12 1 82	7.34	5.00	5.00	6.05	6.43	5.00
12 2 82	8.51	5.00	5.10	5.00	6.43	5.00
12 3 82	6.59		5.00	5.00		5.00

RESULTS OF ARSENIC ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM PITTSFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
9 17 82	28.65		5.00	5.00		5.00
9 20 82	27.43		9.58	5.00		5.00
9 21 82	27.43		6.59	5.00		5.00
9 22 82	7.95		5.10	5.00		5.00
9 23 82				5.00		8.41
9 24 82	25.00		9.58	5.00		5.00
9 27 82	31.09		5.52	5.00		5.96
9 28 82	25.00		5.10	5.00		5.00
9 29 82	20.13		6.74	5.00		7.19
9 30 82	28.65		9.17	5.00		5.96
10 1 82	26.22		7.95	5.00		5.00
10 4 82	20.13		9.17	5.00		5.00
10 5 82	22.56		7.95	5.00		5.96
10 6 82	20.13		7.95	5.00		5.00
10 7 82	7.95		7.95	5.00		5.00
10 8 82	17.69	7.08	9.17	5.00	5.00	5.00
10 12 82	15.20	5.97	8.09	6.77	5.00	5.00
10 13 82	14.07	8.19	5.10	5.00	5.00	5.00
10 14 82	18.59	12.64	5.00	8.71	5.00	5.00
10 15 82	11.81	5.97	5.00	10.65	5.00	5.67
10 18 82	11.81	5.97	5.00	5.00	5.00	6.83
10 19 82	11.81	9.31	5.00	5.00	5.00	5.00
10 20 82	14.07	8.19	5.91	10.65	5.00	5.00
10 21 82		12.64	10.19	8.71	5.00	5.00
10 22 82	25.60	15.98	5.00	11.27	5.00	5.00
10 25 82	14.82	9.31	5.00	5.29	5.00	5.00
10 26 82	14.82	11.53	5.00	5.00	5.00	5.00
10 27 82	20.81	5.90	5.35	9.28	5.00	5.00
10 28 82	19.61	10.64	6.59	17.25	6.81	5.00
10 29 82	29.19	8.27	5.35	17.25	5.00	5.95
11 1 82	7.77	5.90	12.66	9.28	5.00	5.00
11 2 82	9.04	5.00	5.08	9.36	5.00	5.00
11 3 82	20.42	11.83	20.24	13.30	6.81	5.00
11 4 82	7.77	7.09	15.90	5.41	8.89	5.00
11 5 82	15.36	8.27	18.07	9.36	6.81	5.00
11 8 82		7.09	13.74	9.36	5.00	5.00
11 9 82	15.36	8.27	5.00	5.00	5.00	5.00
11 10 82	12.83	10.64	5.00	7.39	5.00	5.00
11 12 82	16.94	5.00	5.00	9.36	6.81	5.00
11 15 82	7.08	5.90	5.00	7.33	5.00	6.77

RESULTS OF ARSENIC ANALYSES OF 24-HR COMPOSITE SAMPLES
FROM MEDFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 4 82			9.17			5.00
10 5 82	7.95		5.00	5.00		5.00
10 6 82	5.52		6.74	5.00		7.19
10 7 82	5.00		5.00	5.00		5.00
10 8 82	5.00		5.00	5.00		5.00
10 12 82	10.85		5.00	5.00		5.67
10 13 82			5.00			5.00
10 14 82	8.42		5.00	5.00		5.00
10 15 82	7.29		5.00	5.00		5.00
10 18 82	6.16		5.00	5.00		5.00
10 19 82	9.55		5.00	5.00		5.00
10 20 82	5.03		5.00	5.00		5.00
10 21 82	10.03		5.00	7.28		5.00
10 22 82	5.24		5.00	5.29		5.00
10 25 82	6.44			7.28		
10 26 82	5.00		5.00	5.00		5.00
10 27 82	5.00		5.00	5.00		5.00
10 28 82	10.03		5.00	11.27		5.00
10 29 82	5.00		5.00	5.00		5.00
11 1 82	5.00		7.24	5.00		5.00
11 2 82	10.30		14.82	5.00		5.00
11 3 82			5.00			5.0C
11 4 82		5.90			5.00	
11 5 82	10.30	5.00	12.66	9.36	5.00	5.00
11 9 82	7.77	5.00		5.41	5.00	
11 10 82	11.57	7.09		5.00	5.00	
11 11 82	13.24	5.00	5.00	5.41	5.00	5.00
11 12 82	14.47	5.00	5.00	9.11	5.00	5.00
11 15 82	5.00	7.09	5.00	5.00	5.00	5.00
11 16 82	5.00	5.00	5.00	5.00	5.00	5.68
11 17 82	5.00	5.00	6.96	5.00	5.00	5.68
11 18 82	7.08	5.00	5.47	5.00	5.00	5.00
11 19 82	5.00	5.00	5.00	5.00	5.00	5.00
11 23 82	5.00	5.00	21.94	5.00	5.00	6.77
11 29 82	6.16	5.00	5.00	7.33	5.00	5.00
11 30 82	7.34	5.00	5.00	8.12	5.00	5.00
12 1 82	6.16	5.00	5.00	8.12	5.00	5.00
12 2 82	8.51	5.77	5.00	6.05	5.32	5.00
12 3 82		5.00	5.00		5.00	5.00
12 6 82	7.34	5.00	5.00	6.05	5.00	5.00
12 7 82	7.34	8.09	5.00	6.05	5.00	5.00
12 8 82	5.00	5.00	5.00	5.00	5.00	5.00
12 9 82	6.16	5.00	5.00	5.00	5.00	5.00
12 10 82		9.58			7.54	
12 13 82	5.00	5.00	5.00	5.00	5.32	5.00
12 14 82	5.00	5.00	5.00	5.00	6.43	5.00
12 15 82		7.04	5.00			5.00

RESULTS OF CADMIUM ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM FITCHBURG TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 5 82	15.84	3.02	0.50	1.60	14.35	4.58
10 6 82	6.26	4.63	0.50	3.60	9.56	2.47
10 7 82	5.32	5.78	1.71	8.02	7.79	2.07
10 8 82	4.63	5.37	0.72	2.82	8.09	
10 13 82	2.80	1.88	0.50	8.15	2.09	1.23
10 14 82	4.17	4.00	0.50	2.53	2.86	1.31
10 15 82	6.18	6.72	0.50	1.99	1.74	2.84
10 16 82	4.76	7.52	0.50	1.23	2.00	2.77
10 17 82	7.36	1.96	0.50	1.36	1.56	2.62
10 18 82	4.95	2.91	0.50	1.27	2.56	2.58
10 19 82	2.79	0.50	0.50	0.80		2.54
10 20 82	4.70	1.73	0.50	3.72	1.90	
10 21 82	6.85		0.50			2.06
10 22 82	6.78		0.50	1.08		1.95
10 23 82	6.36		0.79	1.76		2.69
10 24 82	11.36		0.50	1.32		1.83
10 25 82	5.90		0.50	0.89		1.87
10 26 82	4.97		0.50	1.04		0.88
10 27 82	2.41		0.50	0.50		1.67
10 28 82	10.83		0.50	0.77		
10 29 82	4.59		0.50	0.55		2.03
10 30 82	3.43		0.50	0.50		1.05
10 31 82	0.50		0.50	0.50		1.98
11 1 82	6.78		0.50	1.24	0.84	0.80
11 2 82	10.85		0.50	0.50	2.83	1.22
11 3 82	7.51		0.50	0.82		1.82
11 4 82			0.50			11.61
11 5 82	7.83		0.50	0.55		7.45
11 6 82	7.10		0.50	0.63		1.26
11 7 82	6.45		2.53	1.27		1.43
11 8 82	5.14		0.50	0.50		1.27
11 9 82	4.33		0.50	0.71	1.78	0.99
11 10 82	71.40		0.50	0.50	2.36	0.85
11 11 82	5.61		2.85	1.39		0.71
11 12 82	15.11		0.50	0.90		1.02
11 13 82	4.11		0.50	8.40		0.50
11 14 82	2.05		0.50	4.58		2.38
11 15 82	0.50		0.50	0.50		0.92
11 16 82	3.71		0.50	0.91		0.71
11 17 82	5.19		0.50	2.65		1.30
11 18 82	4.84		0.50	2.95		1.13
11 19 82	5.96		6.94	2.65		2.38
11 20 82	5.49	16.61	0.50	3.03	2.05	1.91
11 21 82	7.71	2.16	0.50	1.74	2.53	1.52
11 22 82	6.52	2.13	0.50	2.69	1.62	2.09
11 27 82	1.47	1.11		0.83	1.09	1.37
11 28 82	4.49		0.50	0.94		1.44
11 29 82	0.98			0.65		1.30
11 30 82	0.50	3.27	0.50	0.50	1.32	1.52
12 1 82	1.62	2.21	0.50	0.72	0.90	1.80
12 2 82	2.04	2.13	0.50	0.98	2.40	4.10
12 3 82	5.49		0.50	0.68		1.08

RESULTS OF CADMIUM ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM PITTSFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
9 17 82	17.78		4.29	8.71		5.96
9 20 82	10.35		4.04	0.50		2.61
9 21 82	15.81		4.04	1.78		2.75
9 22 82	8.31		4.41	1.65		3.94
9 23 82				2.43		6.14
9 24 82	16.78		5.39	6.46		2.89
9 27 82	11.97		5.08	1.20		3.90
9 28 82	14.44		3.98	4.77		3.35
9 29 82	14.44		5.14	3.60		4.41
9 30 82	22.76		5.14	12.94		5.04
10 1 82	16.92		4.90	12.20		4.67
10 4 82	12.61		3.73	3.73		5.41
10 5 82	40.29		5.51	8.90		5.41
10 6 82	34.97		3.21	10.18		5.41
10 7 82	15.61		3.82	8.67		5.09
10 8 82	16.27	21.43	4.00	2.48	13.70	4.76
10 12 82	10.81	13.30	1.71	4.51	12.81	4.93
10 13 82	13.74	4.03	1.38	4.51	1.97	1.47
10 14 82	13.39	5.75	1.63	4.72	4.94	4.33
10 15 82	10.37	7.98	1.48	3.25	11.45	2.49
10 18 82	10.27	2.41	0.50	2.17	1.56	2.54
10 19 82	89.93	15.14	1.71	1.59	4.67	12.87
10 20 82	17.52	13.04	4.05	14.74	10.50	2.69
10 21 82		5.95	4.73	2.91	2.98	2.56
10 22 82	14.86	6.15	3.03	5.06	3.90	5.38
10 25 82	15.50	3.65	2.09	1.23	1.63	3.66
10 26 82	18.60	6.53	2.55	2.33	2.89	1.95
10 27 82	68.58	15.88	3.93	14.66	12.40	3.19
10 28 82	20.00	11.69	3.69	4.64	2.02	5.23
10 29 82	65.78	12.44	4.33	10.56	7.43	4.91
11 1 82	13.37	3.50	3.36	0.60	1.95	2.62
11 2 82	13.81	7.46	2.39	6.95	3.04	1.65
11 3 82	18.94	16.03	9.60	6.33		4.13
11 4 82	18.18	7.61	4.10	5.16	5.97	5.60
11 5 82	20.39	7.10	3.45	4.67	8.89	5.58
11 8 82	11.99	5.37	3.29	1.19	1.25	3.17
11 9 82	12.12	11.99	6.45	2.62	7.72	2.35
11 10 82	17.45	8.54	16.33	2.57	8.60	5.05
11 12 82	17.21	4.91	7.62	2.11	5.09	4.91
11 15 82	7.22	5.37	2.76	4.51	4.50	1.97

RESULTS OF CADMIUM ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM MEDFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 4 82			2.88	3.23		4.18
10 5 82	15.52		0.53			3.26
10 6 82	9.17		0.67	2.69		4.67
10 7 82	11.75		0.50	10.75		8.19
10 8 82	2.74		0.58			2.07
10 12 82	13.21		1.88	1.96		2.37
10 13 82			0.50			1.56
10 14 82	2.20		2.49	2.19		0.50
10 15 82	3.84		0.50	1.68		2.16
10 18 82	2.19		1.62	1.09		0.98
10 19 82	4.53		0.50	1.52		1.63
10 20 82	7.03		1.12	2.96		2.69
10 21 82	17.82		0.50	4.36		1.75
10 22 82	5.03		0.50			2.61
10 25 82	9.85					
10 26 82	7.82		0.50	1.47		1.71
10 27 82	4.28		0.50	1.95		0.97
10 28 82	8.28		0.50	0.50		2.30
10 29 82	6.13		0.50	0.50		1.48
11 1 82	5.51		0.50	0.61		0.93
11 2 82	6.61		0.50	1.40		0.63
11 3 82			0.50			0.50
11 4 82		9.00			7.87	
11 5 82	5.23	6.50	0.50	1.14		3.00
11 9 82	5.06	1.28		1.01	1.78	
11 10 82	10.52	1.51		1.01	1.14	
11 11 82	11.67	3.70	0.50	0.67	1.60	1.27
11 12 82	8.13	2.19	0.50	1.09	1.78	0.50
11 15 82	4.97	2.57	0.50	9.16	11.71	0.88
11 16 82	11.06	1.16	0.50	2.00	2.39	1.13
11 17 82	10.57	3.01	0.50	1.54	2.59	1.09
11 18 82	4.17	2.07	0.50	2.95	4.21	0.99
11 19 82	8.55	6.05	0.50	3.71	1.33	1.51
11 23 82	2.80	5.14	0.50	3.41	1.81	1.94
11 29 82	1.59	40.11		1.44	1.96	1.88
11 30 82	5.83	2.39	0.50	0.72	1.33	1.37
12 1 82	0.50	2.21	0.50	0.56	0.95	1.59
12 2 82	1.40	7.12	0.50	0.56	1.33	2.06
12 3 82		5.39	0.50		2.34	1.66
12 6 82	3.25	0.50	0.50	0.61		1.73
12 7 82	4.34	2.82	0.50	0.82	1.48	2.96
12 8 82	2.15	1.84	0.50	1.44	2.20	
12 9 82	0.50	1.53	0.50	0.50	1.33	1.88
12 10 82		2.94				
12 13 82	9.14	2.27	0.50	0.85	2.38	1.23
12 14 82	4.40	2.51	0.50	1.09	0.96	0.90
12 15 82		2.69	0.50			1.80

RESULTS OF CHROMIUM ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM FITCHBURG TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 5 82	157.70	125.68	14.42	3.00	9.83	3.00
10 6 82	246.36	43.17	9.70	3.29	35.54	3.00
10 7 82	218.25	169.80	4.77	3.29	42.35	3.51
10 8 82	203.11	20.05	4.77	8.13	9.83	
10 13 82	14.92	113.00	14.02	14.39	37.88	3.00
10 14 82	220.41	161.59	36.22	11.28	13.10	3.00
10 15 82	17.25	208.50	19.66	5.05	60.62	3.00
10 16 82	131.75	119.34	11.42	3.00	8.89	3.00
10 17 82	27.95	54.02	17.37	3.00	5.15	3.00
10 18 82	57.24	46.93	17.37	3.00	3.28	3.00
10 19 82	101.48	167.93	19.20	78.68		3.00
10 20 82	179.33	49.63	18.28	16.22	43.02	
10 21 82	101.18		16.45			3.00
10 22 82	346.73		14.62	7.20		3.00
10 23 82	307.35		16.45	3.00		3.00
10 24 82	167.35		15.08	3.00		3.00
10 25 82	184.85		22.86	3.87		3.00
10 26 82	337.98		20.02	24.30		3.00
10 27 82	294.23		31.33	56.64		3.29
10 28 82	232.98		16.54	10.03		3.00
10 29 82	79.85		14.36	5.68		3.00
10 30 82	101.64		19.15	4.89		3.00
10 31 82	33.27		17.84	3.00		3.00
11 1 82	46.92		22.63	3.00		3.00
11 2 82	443.90		18.19	14.77		3.00
11 3 82	443.90		28.57	4.50		3.00
11 4 82			20.78			5.57
11 5 82	430.78		13.00	13.19		4.15
11 6 82	99.45		4.35	3.00		3.00
11 7 82	108.63		9.54	3.00		3.00
11 8 82	31.61		10.84	3.00		3.00
11 9 82	230.70		18.19	3.00		3.00
11 10 82	518.28		12.57	3.00		3.00
11 11 82	242.65		3.92	3.00		3.00
11 12 82	299.53		4.35	3.65		3.00
11 13 82	71.42		19.83	3.00		3.00
11 14 82	53.48		12.35	3.00		3.00
11 15 82	118.94		22.47	3.00		3.00
11 16 82	53.48		13.48	3.00		3.00
11 17 82	196.63		21.59	3.00		3.00
11 18 82	217.25		16.75	7.31		3.00
11 19 82	196.63		24.67	24.00		3.00
11 20 82	209.00	436.20	19.39	6.11	6.37	3.00
11 21 82	258.50	209.58	12.79	3.00	3.00	3.00
11 22 82	74.14	154.08	16.31	3.00	3.00	3.00
11 27 82	90.06	177.20	40.95	24.40	29.51	3.00
11 28 82	18.08		17.63	3.00		3.00
11 29 82	8.10		53.71	3.00		3.00
11 30 82	70.58	214.20	43.15	3.73	5.48	3.00
12 1 82	103.13	31.39	6.05	6.11	3.00	3.00
12 2 82	192.89	200.33	21.54	35.92	45.08	5.20
12 3 82	142.79		14.02	8.90		3.00

RESULTS OF CHROMIUM ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM PITTSFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
9 17 82	48.47		3.00	4.72		3.00
9 20 82	32.20		3.00	3.00		3.00
9 21 82	44.29		3.00	3.00		3.30
9 22 82	28.48		3.55	3.00		3.00
9 23 82	42.78		10.53	6.94		3.00
9 24 82	45.68		3.00	9.15		3.30
9 27 82	33.59		3.00	3.00		3.00
9 28 82	45.22		3.00	9.59		3.00
9 29 82	49.87		3.65	6.49		3.00
9 30 82	71.26		3.00	15.34		3.00
10 1 82	61.96		4.50	22.86		4.19
10 4 82	38.71		3.00	3.00		3.00
10 5 82	74.98		3.00	16.49		3.00
10 6 82	51.73		4.03	7.32		3.30
10 7 82	60.10		3.08	34.09		3.00
10 8 82	68.47	129.80	4.97	5.93	13.10	3.00
10 12 82	33.06	33.27	3.38	3.00	3.00	3.00
10 13 82	34.45	18.01	3.00	4.17	3.75	3.00
10 14 82	43.75	15.95	5.70	4.61	4.22	3.00
10 15 82	47.47	19.25	6.62	3.00	3.00	3.00
10 18 82	45.25	13.47	3.00	3.00	3.00	3.00
10 19 82	32.59	18.12	4.08	3.00	3.00	5.37
10 20 82	56.31	38.16	4.51	33.80	24.79	4.51
10 21 82		69.89	9.13	27.62	24.16	6.13
10 22 82	73.83	36.07	8.22	6.25	7.78	7.07
10 25 82	71.62	16.45	3.64	3.00	3.00	3.00
10 26 82	66.00	17.70	3.49	7.67	4.14	3.00
10 27 82	75.13	34.82	4.36	5.77	12.78	3.00
10 28 82	83.68	30.64	7.84	15.95	14.15	3.76
10 29 82	112.12	29.81	9.14	18.72	15.51	5.18
11 1 82	22.89	7.68	8.71	3.00	3.00	3.00
11 2 82	67.87	37.74	16.97	28.99	23.70	3.00
11 3 82	52.30	21.46	9.58	6.87	5.96	5.57
11 4 82	75.39	36.91	6.51	16.35	11.87	6.51
11 5 82	73.20	24.15	7.38	13.58	13.24	5.57
11 8 82	27.26	7.41	4.35	3.00	3.00	3.22
11 9 82	49.11	22.79	3.00	4.03	7.32	3.00
11 10 82	66.61	46.32	12.57	6.38	27.80	3.00
11 12 82	57.89	14.65	10.84	10.28	3.00	3.00
11 15 82	26.80	8.31	3.48	3.00	3.00	3.00

RESULTS OF CHROMIUM ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM MEDFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 4 82			3.00			3.00
10 5 82	21.97		3.00	5.05		3.00
10 6 82	22.43		3.00	3.00		3.00
10 7 82	20.11		3.00	12.97		3.00
10 8 82	10.81		3.00	3.00		3.00
10 12 82	10.74		3.00	3.00		3.00
10 13 82			3.00			3.00
10 14 82	8.81		3.00	3.00		3.00
10 15 82	53.05		3.00	3.00		3.00
10 18 82	10.96		3.00	4.08		3.00
10 19 82	78.63		3.00	3.00		3.00
10 20 82	21.90		3.00	3.00		3.00
10 21 82	21.19		3.00	3.00		3.00
10 22 82	20.32		3.00	3.00		3.00
10 25 82	36.85			3.00		
10 26 82	29.89		3.00	3.00		3.00
10 27 82	11.62		3.00	3.00		3.00
10 28 82	39.46		3.00	3.00		3.00
10 29 82	30.33		3.00	4.89		3.00
11 1 82	8.18		4.36	3.00		3.00
11 2 82	8.86		6.53	3.00		3.00
11 3 82			4.36			3.00
11 4 82		3.00			3.00	3.00
11 5 82	29.42	3.00	3.00	3.00		3.00
11 9 82	10.96	3.00		3.00	3.00	
11 10 82	26.80	3.00		3.00	3.00	
11 11 82	64.86	3.00	3.00	3.00	3.00	3.00
11 12 82	30.73	3.00		3.65	3.00	3.00
11 15 82	3.61	3.00	3.00	3.00	3.00	3.00
11 16 82	29.86	3.00	3.00	3.00	3.00	3.00
11 17 82	12.36	3.00	3.00	3.00	3.00	3.00
11 18 82	13.67	3.00	3.00	3.00	3.00	3.00
11 19 82	38.61	3.00	3.00	3.00	3.00	3.00
11 23 82	49.64	3.00	3.00	3.00	3.00	3.00
11 29 82	25.58	13.91	30.83	3.00	3.00	3.00
11 30 82	15.45	10.23	3.55	6.51	3.00	3.00
12 1 82	8.02	3.00	3.00	3.33	3.00	3.00
12 2 82	19.83	3.00	3.00	3.00	3.00	3.00
12 3 82		3.00	3.00		3.00	3.00
12 6 82	29.02	11.61	3.00	3.00	3.00	3.00
12 7 82	10.20	10.96	10.50	3.00	3.00	3.00
12 8 82	24.64	3.00	3.00	3.00	3.00	3.00
12 9 82	8.45	3.00	3.00	3.00	3.00	3.00
12 10 82		3.00			3.00	
12 13 82	3.20	3.00	3.00	3.00	3.00	3.00
12 14 82	4.08	3.00	3.00	3.00	3.00	3.00
12 15 82		3.00	3.00		3.00	3.00

RESULTS OF COPPER ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM FITCHBURG TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 5 82	526.65	346.78	10.00	193.07	203.48	10.00
10 6 82	462.75	828.41	10.00	174.27	172.80	10.00
10 7 82	739.65	437.65	10.00	120.93	165.88	10.00
10 8 82	686.40	349.00	14.18	106.24	168.65	
10 13 82	279.05	203.16	45.50	124.19	138.18	10.00
10 14 82	371.18	296.65	49.42	130.72	170.03	10.00
10 15 82	361.96	293.22	45.50	127.46	160.68	22.10
10 16 82	610.70	60.21	37.67	110.32	22.29	10.00
10 17 82	454.09	310.20	48.84	163.36	166.18	75.51
10 18 82	389.60	353.63	45.50	144.59	195.77	16.79
10 19 82	537.00	194.40	38.79	163.80		35.67
10 20 82	380.39	377.75	38.79	190.02	147.46	23.46
10 21 82	509.36		49.88	173.03		14.76
10 22 82	702.83		51.72	177.61		12.00
10 23 82	877.86		97.19	184.89		44.95
10 24 82	610.70		44.33	184.89		10.00
10 25 82	509.68		55.42	184.89		10.00
10 26 82	474.65		58.78	141.23		33.87
10 27 82	451.30		61.66	153.70		33.49
10 28 82	684.80		31.77	143.06		10.15
10 29 82	427.95		31.77	139.11		11.34
10 30 82	603.08		67.63	163.77		16.07
10 31 82	439.63		23.40	145.03		16.07
11 1 82	603.08		46.85	166.73		24.34
11 2 82	589.34		28.43	174.29		38.53
11 3 82	1175.15		35.40	93.75		25.72
11 4 82			37.07			20.80
11 5 82	668.60		62.77	133.20		24.18
11 6 82	494.55		65.20	36.54		36.17
11 7 82	385.10		91.93	164.76		29.07
11 8 82	196.10		33.61	159.83		14.88
11 9 82	347.30		67.63	180.69		43.26
11 10 82	479.60		43.33	172.42		10.00
11 11 82	536.30		53.05	144.08		10.00
11 12 82	583.55		28.75	140.54		10.00
11 13 82	422.90		49.89	158.25		10.00
11 14 82	196.10		28.34	121.64		10.00
11 15 82	201.38		58.51	161.79		10.00
11 16 82	323.27		142.56	143.22		51.57
11 17 82	310.43		60.67	166.52		24.05
11 18 82	437.65		71.44	148.80		29.55
11 19 82	437.65		45.58	170.06		26.80
11 20 82	428.56	490.53	54.20	44.32	290.93	
11 21 82	570.35	278.45	36.96	58.79	64.12	10.00
11 22 82	166.70	253.50	39.12	118.32	116.07	14.88
11 27 82	185.90	110.04	90.77	13.75	103.91	10.00
11 28 82	184.15		32.37	142.45		10.00
11 29 82	184.15		108.29	166.58		10.00
11 30 82	210.46	303.40	290.93	49.14	10.00	23.49
12 1 82	192.01	230.24	90.77	139.23	46.44	56.34
12 2 82	474.00	241.03	49.89	25.01	130.43	23.49
12 3 82	196.37		36.75	160.15		16.19

RESULTS OF COPPER ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM PITTSFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
9 17 82	675.75		42.88	190.10		46.63
9 20 82	462.75		48.51	58.56		25.97
9 21 82	398.85		29.73	10.00		22.22
9 22 82	196.50		54.84	19.99		47.15
9 23 82				137.68		67.90
9 24 82	387.85		56.85	109.00		51.13
9 27 82	441.45		59.75	102.08		39.95
9 28 82	494.70		54.84	126.80		34.36
9 29 82	622.50		62.85	110.98		67.87
9 30 82	697.05		78.86	140.65		57.90
10 1 82	654.45		71.05	142.63		69.30
10 4 82	569.25		64.85	139.66		77.42
10 5 82	665.10		40.84	93.18		32.96
10 6 82	655.10		52.84	119.88		98.43
10 7 82	547.95		64.84	134.71		49.98
10 8 82	643.80	264.99	82.86	117.90	142.33	71.69
10 12 82	526.65	264.97	47.46	62.18	98.01	10.00
10 13 82	484.05	168.03	68.85	75.23	125.71	73.60
10 14 82	444.88	255.90	76.82	98.08	131.25	63.26
10 15 82	343.54	234.33	90.87	110.32	153.41	99.10
10 18 82	435.66	132.93	80.74	77.68	127.10	64.58
10 19 82	500.15	77.47	84.65	145.56	164.58	31.17
10 20 82	444.88	275.96	92.37	150.87	191.87	82.58
10 21 82		146.15	100.76	107.40	140.45	100.76
10 22 82	629.13	284.59	115.56	124.19	129.41	113.71
10 25 82	490.94		98.86	148.61		83.12
10 26 82	649.78	317.43	81.28	194.40	130.84	73.60
10 27 82	754.85	327.81	86.83	168.45	164.14	10.00
10 28 82	813.23	327.81	93.88	198.98	207.95	108.62
10 29 82	1322.90	317.43	123.91	198.98	199.18	118.26
11 1 82	474.65	275.88	83.70	52.32	190.42	72.83
11 2 82	801.55	275.88	46.85	223.49	165.89	47.13
11 3 82	708.15	452.46	93.75	173.63	185.17	10.00
11 4 82	611.90	358.98	117.20	174.62	34.45	72.83
11 5 82	741.38	317.43	113.85	143.22	176.40	38.53
11 8 82	517.40	288.52	108.94	131.22	10.00	64.55
11 9 82	498.50	348.59	99.22	144.05	134.99	66.91
11 10 82	536.30	379.75	179.41	138.13	141.23	163.88
11 12 82	517.40	348.59	164.83	167.70	195.68	75.43
11 15 82	441.80	203.60	117.77	128.73	111.65	61.67

RESULTS OF COPPER ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM MEDFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 4 82			20.82			20.12
10 5 82	867.45		16.82	25.92		16.30
10 6 82	633.15		10.00	24.93		10.00
10 7 82	168.55		10.00	67.46		10.00
10 8 82	139.18		10.00	23.01		10.00
10 12 82	196.62		22.01	27.09		15.46
10 13 82			36.83			14.39
10 14 82	260.63		36.83	71.97		10.57
10 15 82	242.20		22.01	57.28		18.12
10 18 82	162.78		14.18	10.77		10.00
10 19 82	176.97		11.08	10.00		10.00
10 20 82	147.82		28.72	27.18		10.00
10 21 82	158.23		7.13	38.72		29.94
10 22 82	610.70		18.47	26.51		10.00
10 25 82	172.81			107.40		
10 26 82	462.98		22.16	78.85		10.00
10 27 82	101.05		18.47	47.88		10.00
10 28 82	544.70		37.07	130.29		19.20
10 29 82	544.70		35.40	75.99		19.20
11 1 82	163.48		16.70	147.00		10.00
11 2 82	498.00		10.00	42.46		10.00
11 3 82			10.00			10.00
11 4 82		45.28			10.00	
11 5 82	422.90	38.54	10.00	82.90	16.93	15.94
11 9 82	611.90	19.04		96.84	12.04	
11 10 82	933.20	47.76		53.14	44.96	
11 11 82	1790.80	40.85	23.89	43.69	16.93	13.04
11 12 82	460.70	20.10	10.00	40.15	10.00	10.00
11 15 82	127.85	12.54	28.72	49.60	10.32	17.57
11 16 82	275.76	10.59	10.00	24.12	13.77	10.00
11 17 82	161.20	10.00	10.00	27.16	10.00	10.00
11 18 82	46.89	10.59	11.10	34.25	10.00	10.00
11 19 82	255.90	10.00	11.10	31.88	24.33	10.00
11 23 82	155.94	10.00	10.00	44.88	10.00	10.00
11 29 82	140.53	10.00	61.57	18.57	10.00	14.36
11 30 82	226.26	10.00	10.00	53.47	18.95	10.00
12 1 82	74.15	10.00	10.00	58.79	10.00	10.00
12 2 82	228.25	10.00	10.00	18.95	10.00	10.00
12 3 82		10.00	10.00		10.00	10.00
12 6 82	152.89	10.00	10.00	17.22	10.00	10.00
12 7 82	144.02	10.00	10.00	31.45	10.00	10.00
12 8 82	191.13	10.00	10.00	12.14	10.00	10.00
12 9 82	146.85	10.00	37.07	12.14	10.00	24.09
12 10 82		17.14			10.00	
12 13 82	134.32	20.34	10.00	16.97	10.32	10.00
12 14 82	146.22	12.54	42.08		24.12	37.13
12 15 82		25.39	10.00		34.34	10.00

RESULTS OF MERCURY ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM FITCHBURG TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 5 82	0.32	0.26	0.20	0.20	0.20	0.20
10 6 82	0.26	0.65	0.20	0.20	0.20	0.26
10 7 82	0.26	0.26	0.20			0.20
10 8 82	0.32	0.26	0.20	0.20	0.26	
10 13 82	0.20	0.20	0.20	0.20		0.20
10 14 82	0.39	0.32	0.20	0.20	0.20	0.20
10 15 82	0.34	0.25	0.20	0.25	0.20	0.20
10 16 82	0.34	0.25	0.20	0.20	0.20	0.20
10 17 82	0.34	0.34	0.20	0.34	0.20	0.20
10 18 82	0.51	0.34	0.20	0.25	0.20	0.20
10 19 82	0.20	0.20	0.20	0.25		0.20
10 20 82	0.20	0.25	0.20	0.20	0.20	0.20
10 21 82	0.25		0.20	0.20		0.20
10 22 82	0.25		0.20	0.20		0.20
10 23 82	0.34		0.20	0.20		0.20
10 24 82	0.25		0.20	0.20		0.20
10 25 82	0.25		0.20	0.20		0.20
10 26 82	0.25		0.20	0.25		0.20
10 27 82	0.25		0.25	0.25		0.20
10 28 82	0.31		0.20	0.20		0.20
10 29 82	0.24		0.20	0.20		0.20
10 30 82	0.31		0.20	0.20		0.20
10 31 82	0.31		0.20	0.20		0.20
11 1 82	0.31	0.23	0.20	0.20	0.20	0.20
11 2 82	0.31	0.62	0.20	0.20	0.23	0.20
11 3 82	0.63		0.20	0.20		0.20
11 4 82			0.20			0.20
11 5 82	0.47		0.20	0.20		0.20
11 6 82	0.20		0.20	0.20		0.20
11 7 82	0.53		0.20	0.20		0.20
11 8 82	0.20		0.20	0.20		0.20
11 9 82	0.44	0.20	0.20	0.20	0.20	0.20
11 10 82	0.53	0.20	0.20	0.20	0.20	0.20
11 11 82	0.70		0.20	0.26		0.20
11 12 82	0.44		0.20	0.20		0.20
11 13 82	0.35		0.20	0.20		0.20
11 14 82	0.20		0.20	0.20		0.20
11 15 82	0.20		0.20	0.20		0.20
11 16 82	0.20			0.20		0.20
11 17 82	0.34		0.20			0.25
11 18 82	0.25		0.20	0.25		0.20
11 19 82	0.43		0.20	0.20		0.20
11 20 82	0.43	0.34	0.20	0.25	0.20	0.20
11 21 82	0.34	0.43	0.34	0.20	0.20	0.20
11 22 82	0.34	0.34	0.20	0.20	0.20	0.20
11 27 82	0.34	0.20	0.20	0.20	0.20	0.20
11 28 82	0.20		0.20	0.20		0.20
11 29 82	0.25		0.20	0.20		0.20
11 30 82	0.20	0.25	0.34	0.20	0.20	0.20
12 1 82	0.20	0.20	0.20	0.20	0.20	0.20
12 2 82	0.25	0.20	0.34	0.20	0.20	0.20
12 3 82	0.20		0.20	0.20		0.20

RESULTS OF MERCURY ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM PITTSFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
9 17 82	0.91		0.20	1.04		0.91
9 20 82	0.52		0.65	0.52		0.58
9 21 82	0.91		0.20	0.20		0.39
9 22 82	0.84		0.20	0.26		
9 23 82			0.20	0.20		0.45
9 24 82				0.26		0.20
9 27 82	0.65		0.20	0.20		0.20
9 28 82	0.65		0.20	0.20		0.20
9 29 82	0.58		0.20			0.20
9 30 82	0.65		0.26			0.26
10 1 82	1.04		0.20	0.39		0.26
10 4 82	0.65		0.20			0.20
10 5 82	0.97		0.20	0.20		0.20
10 6 82	0.65		0.20	0.20		0.20
10 7 82	0.45		0.20	0.20		0.20
10 8 82	0.26		0.20	0.20	0.26	0.20
10 12 82	0.32	0.26	0.20			0.20
10 13 82	0.26	0.20	0.25	0.20	0.20	0.20
10 14 82	0.39	0.20	0.34	0.20	0.20	0.20
10 15 82	0.25	0.20	0.20	0.20	0.20	0.20
10 18 82	0.25	0.25	0.20	0.20	0.20	0.20
10 19 82	0.25	0.20	0.20	0.25	0.20	0.20
10 20 82	0.51	0.20	0.20	0.20	0.25	0.25
10 21 82	0.85	0.34	0.20	0.20	0.20	0.20
10 22 82	0.68	0.34	0.20	0.25	0.20	0.20
10 25 82	0.51	0.20	0.20	0.20	0.20	0.20
10 26 82	0.68	0.25	0.25	0.20	0.20	0.34
10 27 82	0.42		0.20	0.51	0.20	0.20
10 28 82	0.94	0.23	0.20	0.20	0.20	0.20
10 29 82	0.79	0.23	0.20	0.20	0.20	0.20
11 1 82	0.31	0.20	0.20	0.20	0.20	0.20
11 2 82	0.47	0.20	0.63	0.24	0.20	0.20
11 3 82	0.47	0.20	0.20	0.20	0.20	0.20
11 4 82	0.39	0.23	0.20	0.31	0.20	0.20
11 5 82	1.10	0.23	0.20	0.20	0.20	0.20
11 8 82	0.44	0.20	0.20	0.20	0.20	0.20
11 9 82	0.53	0.20	0.20	0.35	0.20	0.20
11 10 82	0.44	0.20	0.20	0.20	0.20	0.20
11 12 82	0.44	0.20	0.20	0.20	0.20	0.20
11 15 82	0.35	0.20	0.20	0.20		0.20

RESULTS OF MERCURY ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM MEDFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 4 82			0.20			0.20
10 5 82	0.20		0.20			0.20
10 6 82	1.23		0.20	0.26		0.20
10 7 82	0.45		0.20			0.20
10 8 82	0.39		0.26			0.39
10 12 82	0.78		0.20	0.26		0.77
10 13 82			0.20			0.20
10 14 82	0.84		0.20	0.20		0.20
10 15 82	0.20		0.20	0.20		0.20
10 18 82	0.42		0.20	0.20		0.20
10 19 82	0.34		0.20	0.25		0.20
10 20 82	0.25		0.20	0.20		0.20
10 21 82	1.18		0.20	0.20		0.20
10 22 82	0.59		0.20	0.20		0.20
10 25 82	1.01			0.20		
10 26 82	1.18		0.25	0.20		0.20
10 27 82	1.01		0.20	0.25		0.20
10 28 82	1.10		0.20	0.20		0.20
10 29 82	1.26		0.20	0.20		0.20
11 1 82	0.94		0.20	0.24		0.20
11 2 82	1.10		0.20	0.20		0.20
11 3 82			0.20			0.20
11 4 82		0.20			0.20	
11 5 82	2.20	0.23	0.20	0.31	0.20	0.20
11 9 82	1.31	0.20		0.26	0.26	
11 10 82	1.14	0.20		0.20	0.20	
11 11 82	3.24	0.20	0.20	0.20	0.20	0.20
11 12 82	3.15	0.20	0.20	0.20	0.20	0.20
11 15 82	0.53	0.20	0.20	0.20	0.20	0.20
11 16 82	0.61	0.20	0.20	0.20	0.20	0.20
11 17 82	1.05	0.20	0.20	0.20	0.20	0.20
11 18 82	1.19	0.25	0.20		0.20	0.20
11 19 82	2.55	0.20	0.20	0.51	0.20	0.25
11 23 82	1.53	0.20	0.20	0.20	0.20	0.20
11 29 82	2.04	0.25	0.20	0.20	0.20	0.20
11 30 82	2.04	0.20	0.20	0.20	0.20	0.20
12 1 82	2.04	0.20	0.20	0.20	0.20	0.20
12 2 82	1.02	0.20		0.20	0.20	0.20
12 3 82	4.16	0.20	0.20		0.20	0.20
12 6 82	1.19		0.20	0.20	0.20	0.20
12 7 82	1.02	0.25	0.20	0.25	0.20	0.20
12 8 82	1.44	0.20	0.20		0.20	0.20
12 9 82	0.85	0.20	0.20	0.20	0.20	0.20
12 10 82		0.20			0.20	
12 13 82	0.68	0.20	0.20	0.20	0.20	0.20
12 14 82	1.02	0.20	0.20	0.20	0.20	0.20
12 15 82	1.02	0.20	0.20		0.20	0.20

RESULTS OF LEAD ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM FITCHBURG TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 5 82	1223.85	833.21	53.42	62.07	64.77	5.00
10 6 82	1334.07	441.03	33.54	67.43	48.97	21.83
10 7 82	949.30	796.13	15.35	83.51	64.77	30.79
10 8 82	866.50	870.29	58.64	92.61	72.67	
10 13 82	1032.10	962.99	32.18	69.13	45.31	5.00
10 14 82	976.90	1166.93	77.88	84.78	69.46	16.71
10 15 82	1148.30	870.94	111.55	75.00	42.90	6.64
10 16 82	728.50	344.63	97.12	35.85	16.33	30.79
10 17 82	108.73	366.87	92.31	18.23	5.00	10.67
10 18 82	114.25	277.88	70.66	6.49	5.00	14.69
10 19 82	78.29	183.44	49.03	5.00		5.00
10 20 82	1269.10	220.16	58.83	45.63	6.67	
10 21 82	634.30		15.96			26.77
10 22 82	1351.80		53.93	80.42		79.09
10 23 82	157.27		63.73	93.98		71.04
10 24 82	68.95		60.06	80.42		44.88
10 25 82	49.63		75.98	15.32		18.72
10 26 82	1673.30		73.53	123.82		12.68
10 27 82	786.26		147.98	42.44		34.82
10 28 82	1324.82		152.02	118.40		32.39
10 29 82	374.42		191.71	50.58		81.67
10 30 82	266.94		112.33	32.33		36.87
10 31 82	118.51		81.46	5.00		50.31
11 1 82	1778.73		96.89	5.00		27.91
11 2 82	1742.73		68.23	28.38		13.98
11 3 82	1730.00		138.79	12.56		54.79
11 4 82			118.30			50.31
11 5 82	1850.72		113.57	50.13		30.15
11 6 82	1238.80		112.00	5.00		18.95
11 7 82	680.88		168.70	26.40		18.95
11 8 82	41.85		58.45	5.00		9.99
11 9 82	667.20		113.57	12.56		5.00
11 10 82	2861.93		105.70	67.93		5.00
11 11 82	1002.50		115.15	61.35		5.55
11 12 82	853.51		72.63	22.05		7.66
11 13 82	425.08		83.98	5.00		22.47
11 14 82	276.06		41.45	55.74		9.78
11 15 82	536.85		93.43	5.21		5.00
11 16 82	369.20		102.88	30.47		5.00
11 17 82	1021.16		109.97	30.47		5.00
11 18 82	1207.43		83.98	24.86		5.00
11 19 82	1095.67		119.42	33.28		22.47
11 20 82	1227.75	1841.40	133.59	44.51	6.75	14.01
11 21 82	1299.60	748.60	126.50	5.00	44.03	7.08
11 22 82	245.55	475.40	86.34	66.97	10.30	7.08
11 27 82	267.10	577.90	505.50	8.01	6.51	7.08
11 28 82	53.33		77.95	17.37		14.60
11 29 82	53.33		568.58	11.44		10.84
11 30 82	335.36	919.40	568.48	17.37	21.89	7.08
12 1 82	1012.20	129.50	115.28	17.37	5.00	10.84
12 2 82	760.72	6.56	108.17	41.07	186.70	14.60
12 3 82	688.88		88.61	64.77		37.16

RESULTS OF LEAD ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM PITTSFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
9 17 82	93.24		5.00	21.87		5.00
9 20 82	60.54		5.00	5.00		5.00
9 21 82	85.90		5.00	5.00		5.00
9 22 82	26.12		5.00	5.79		5.00
9 23 82				13.83		5.00
9 24 82	85.90		5.00	64.75		5.00
9 27 82	71.41		10.82	5.00		5.00
9 28 82	53.29		7.98	8.47		5.00
9 29 82	75.03		5.00	5.79		5.00
9 30 82	91.33		5.00	5.00		5.00
10 1 82	82.28		5.00	21.87		5.00
10 4 82	53.29		5.00	5.79		5.00
10 5 82	71.41		5.00	51.35		5.00
10 6 82	76.84		5.00	5.00		5.00
10 7 82	65.40		5.00	5.00		5.00
10 8 82	143.87	24.28	10.82	29.91	9.47	5.00
10 12 82	60.04	5.00	5.00	5.00	13.42	5.00
10 13 82	32.38	5.00	5.00	8.44	31.19	5.00
10 14 82	47.11	17.74	5.00	5.00	17.37	5.00
10 15 82	26.85	5.00	5.00	5.00	5.00	5.00
10 18 82	93.24	5.00	5.00	5.00	5.00	5.00
10 19 82	342.10	17.74	5.00	5.00	5.00	10.67
10 20 82	75.61	17.74	18.41	12.36	5.00	12.68
10 21 82		38.82	52.11	5.00		5.00
10 22 82	146.63	35.12	12.28	12.61	5.00	5.00
10 25 82	177.50	11.06	5.00	5.00	5.00	5.00
10 26 82	108.73	13.66	7.38	9.90	5.00	5.00
10 27 82	133.51	28.70	49.03	15.32	5.00	6.64
10 28 82	122.53	18.67	6.49	7.18	5.00	10.67
10 29 82	180.49	17.00	5.00	5.00	5.00	10.67
11 1 82	60.67	5.00	15.31	12.61	5.00	5.00
11 2 82	70.60	5.00	5.00	5.00	5.00	
11 3 82	84.97	11.98	5.00	5.00	5.00	5.00
11 4 82	56.23	15.33	5.00	5.00		5.00
11 5 82	108.93	23.08	11.51	5.00	5.00	9.99
11 8 82	65.81	11.98	5.00	5.00	5.00	5.00
11 9 82	101.74	23.69	39.55	8.60	5.00	5.00
11 10 82	84.97	18.67	156.10	5.00	5.00	5.00
11 12 82	99.40	20.87	99.40	5.00	5.00	5.00
11 15 82	89.78	20.87	74.53	5.21	5.00	5.00

RESULTS OF LEAD ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM MEDFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 4 82			7.98			5.00
10 5 82	118.51		5.00	19.19		5.00
10 6 82	67.90		7.98	5.79		5.00
10 7 82	34.23		5.00	5.00		5.00
10 8 82	15.73		5.00	5.00		5.00
10 12 82	25.01		5.00	5.00		5.00
10 13 82			15.35			5.00
10 14 82	115.36		5.00	5.00		5.00
10 15 82	41.60		5.00	5.00		5.00
10 18 82	56.36		5.00	5.00		5.00
10 19 82	80.50		8.61	5.00		18.72
10 20 82	51.84		25.76	5.00		5.00
10 21 82	58.45		23.31	5.00		5.00
10 22 82	117.98		18.41	5.00		5.00
10 25 82	173.09			23.46		
10 26 82	92.17		26.98	5.00		
10 27 82	42.49		9.83	5.00		6.64
10 28 82	152.89		5.00	12.61		14.69
10 29 82	97.69		5.00	20.74		14.69
11 1 82	27.48		5.00	12.61		5.51
11 2 82	56.23		5.00	5.00		5.00
11 3 82			5.00			5.00
11 4 82		13.66			5.00	
11 5 82	99.34	11.98	5.00	6.63	5.00	5.51
11 9 82	84.97	17.00		5.00	5.00	
11 10 82	266.94	6.56		5.00	5.00	
11 11 82	202.82	6.56	6.47	5.21	5.00	5.00
11 12 82	80.16	5.00		5.21	5.00	5.00
11 15 82	22.44	6.56	5.00	5.00	5.00	5.00
11 16 82	29.66	6.56	5.00	5.00	5.00	5.00
11 17 82	94.59	30.41	5.00	5.00	6.75	5.00
11 18 82	36.87	11.33	5.00	5.21	5.00	5.00
11 19 82	214.84	16.10	5.00	5.00	5.00	5.00
11 23 82	60.92	5.00	20.19	5.00	6.75	5.00
11 29 82	46.68	5.00	35.81	5.21	10.90	5.00
11 30 82	48.28	6.56	5.00	13.42	5.00	7.08
12 1 82	28.10	30.41	5.00	5.00	5.00	7.08
12 2 82	78.56	33.88	5.00	7.49	5.00	7.08
12 3 82		6.56	10.40		5.00	7.08
12 6 82	45.76	5.00	5.00	7.49	5.00	14.60
12 7 82	43.24	16.80	5.00	7.49	5.00	14.60
12 8 82	63.42	5.00	22.85	13.42	5.00	14.60
12 9 82	48.28	6.56	5.00	13.42	5.00	14.60
12 10 82		5.00			5.00	
12 13 82	18.02	5.00	5.00	13.42	5.00	14.60
12 14 82	53.33	5.00	5.00	15.40	5.00	22.12
12 15 82		9.97	5.00		5.00	18.36

RESULTS OF ANTIMONY ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM FITCHBURG TREATMENT PLANT

DATE	UNFILTERED			FILTERED		
	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 5 82	10.00	10.00	10.00	10.00	14.35	11.62
10 6 82	10.00	14.57	12.31	10.38	15.53	10.00
10 7 82	11.04	10.20	10.37	12.98	14.35	10.25
10 8 82	13.54	14.89	10.37	10.00	13.16	
10 13 82	11.50	10.00	10.00	14.28	16.72	10.00
10 14 82	10.48	14.11	12.23	10.00	13.16	10.00
10 15 82	13.54	11.60	10.37	18.18	15.53	10.00
10 16 82	14.56	10.77	11.30	10.38	14.35	10.00
10 17 82	14.56	14.94	10.37	10.00	13.16	11.66
10 18 82	13.54	15.78	12.23	10.00	13.16	10.00
10 19 82	11.50	12.44	11.53	10.59		11.66
10 20 82	16.60	10.77	10.00	10.00	13.16	
10 21 82	14.02		10.00			10.00
10 22 82	11.39		10.40	10.59		10.00
10 23 82	12.71		11.53	10.00		10.00
10 24 82	10.07		10.00	10.00		11.24
10 25 82	10.00		10.00	10.00		10.00
10 26 82	10.07		10.00	13.55		11.24
10 27 82	14.02		18.07	10.00		10.00
10 28 82	21.93		14.63	12.39		
10 29 82	11.39		13.77	10.15		13.07
10 30 82	10.00		10.00	15.76		13.07
10 31 82	10.00		11.19	10.00		17.15
11 1 82	17.34		17.21	10.81	13.80	12.31
11 2 82	14.07		18.07	10.00	13.80	10.00
11 3 82	21.71		18.07	40.66		10.00
11 4 82			11.61			12.31
11 5 82	21.71		10.44	12.30		12.31
11 6 82	19.53		13.93	13.79		10.00
11 7 82	10.00		10.44	13.79		12.31
11 8 82	10.00		13.93	10.00		26.83
11 9 82	14.09		10.00	11.42		12.31
11 10 82	29.89		10.44	14.07		14.73
11 11 82	15.59		15.09	10.00		12.46
11 12 82	12.58		10.00	14.07		10.85
11 13 82	12.58		12.77	10.09		10.85
11 14 82	11.08		10.00	10.00		18.92
11 15 82	14.09		10.00	11.42		10.00
11 16 82	17.10		10.00	10.09		10.00
11 17 82	11.08		10.00	10.00		10.00
11 18 82	15.59		10.00	11.42		10.00
11 19 82	11.08		10.00	15.49		10.00
11 20 82	14.09	15.87	10.00	15.49	13.61	10.99
11 21 82	11.08	13.18	10.00	16.64	16.08	10.00
11 22 82	15.44	10.00	10.00	16.64	16.08	10.00
11 27 82	11.95	11.39	19.37	18.95	19.78	10.00
11 28 82	10.00		13.14	20.10		13.32
11 29 82	18.06		16.88	13.19		15.66
11 30 82	12.82	12.29	13.14	14.34	17.31	10.00
12 1 82	16.31	10.00	13.14	17.80	14.85	10.99
12 2 82	17.18	10.00	10.00	18.95	13.61	15.66
12 3 82	21.55		15.63	16.64		15.66

RESULTS OF ANTIMONY ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM PITTSFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
9 17 82	30.99		10.47	27.80		14.37
9 20 82	28.14		10.47	20.41		15.74
9 21 82	17.69		11.39	20.41		14.37
9 22 82	11.99		10.00	21.64		18.49
9 23 82				22.87		14.37
9 24 82	23.39		10.00	21.64		15.74
9 27 82	17.69		11.39	19.18		14.37
9 28 82	22.44		13.23	15.48		14.37
9 29 82	20.54		10.47	20.41		15.74
9 30 82	25.29		11.39	19.18		17.11
10 1 82	18.64		12.31	15.48		18.49
10 4 82	21.49		14.15	16.71		14.37
10 5 82	21.49		10.00	19.18		11.62
10 6 82	17.69		12.31	12.98		10.25
10 7 82	11.99		11.30	12.98		10.25
10 8 82	15.79	11.95	13.16	16.88	25.03	13.00
10 12 82	19.66	18.11	10.37	10.00	19.09	16.14
10 13 82	15.58	19.72	12.23	11.68	21.47	14.37
10 14 82	15.58	14.11	10.00	12.98	21.47	16.14
10 15 82	16.60	10.77	10.00	12.98	19.09	10.00
10 18 82	17.62	16.61	13.16	11.63	19.09	17.81
10 19 82	19.66	10.00	13.16	10.00	19.09	10.00
10 20 82	17.62	15.78	10.00	15.03	20.28	15.76
10 21 82		12.44	29.49	20.94	26.22	11.66
10 22 82	27.20	10.00	10.40	23.89	19.09	10.00
10 25 82	16.66	10.00	10.00	10.59	20.28	10.00
10 26 82	19.29	11.60	10.00	16.50	20.28	10.00
10 27 82	20.61	10.00	10.00	13.55	19.09	13.07
10 28 82	21.93	14.11	18.07	15.03	22.47	16.75
10 29 82	25.88	17.49	18.07	13.55	23.92	11.24
11 1 82	16.66	10.00	11.19	15.76	28.25	18.59
11 2 82	14.07	11.70	11.19	20.25	16.69	10.00
11 3 82	15.16	10.00	16.35	22.49	28.25	10.00
11 4 82	15.16	17.49	11.19	18.27	25.36	14.73
11 5 82	22.81	15.56	10.33	10.81	16.69	17.15
11 8 82	15.16	15.56	10.44	10.00	19.58	12.31
11 9 82	18.44	13.63	13.93	10.00	23.92	12.31
11 10 82	22.81	11.70	17.42	14.07	14.85	
11 12 82	20.11	19.42	12.77	16.73	16.08	24.41
11 15 82	11.08	11.70	10.00	12.75	23.47	10.85

RESULTS OF ANTIMONY ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM MEDFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 4 82			10.00			10.25
10 5 82	10.00		10.00	18.18		10.00
10 6 82	11.99		11.39	12.98		10.00
10 7 82	11.99		15.02	16.88		10.00
10 8 82	10.00		10.00			
10 12 82	10.48		10.37	14.28		14.37
10 13 82			13.16			16.14
10 14 82	13.54		13.16	16.88		11.66
10 15 82	13.54		13.16	12.98		10.00
10 18 82	11.50		12.23	15.58		10.00
10 19 82	15.58		11.53	20.94		11.66
10 20 82	13.54		11.53	16.50		13.71
10 21 82	10.07		10.00	17.98		11.24
10 22 82	16.66		10.00			11.24
10 25 82	19.29			16.50		
10 26 82	19.29		10.00	15.03		10.00
10 27 82	17.98		10.00	16.50		10.00
10 28 82	17.98		17.21	18.00		14.91
10 29 82	14.02		11.19	20.25		14.91
11 1 82	11.88		14.63	18.00		18.59
11 2 82	14.07		18.07	22.49		10.00
11 3 82			17.21			10.00
11 4 82		14.60			23.92	
11 5 82	15.16	13.63	11.61	10.81		14.73
11 9 82	15.16	11.70		12.75	12.38	
11 10 82	15.16	10.00		15.40	13.61	
11 11 82	20.11	13.63	12.77	11.42	14.85	12.31
11 12 82	14.09	10.00	15.09	16.73	16.08	10.00
11 15 82	10.00	14.60	10.00	14.07	18.54	10.00
11 16 82	12.58	14.60	12.77	11.42	18.54	10.00
11 17 82	15.59	10.00	10.00	10.09	13.61	10.00
11 18 82	16.35	11.70	10.00	12.75	13.61	15.66
11 19 82	11.83	11.70	10.00	14.07	16.08	13.32
11 23 82	15.59	10.00	10.00	11.42	24.71	10.00
11 29 82	10.20	10.00	19.37	20.10	16.08	10.00
11 30 82	18.06	10.50	10.65	22.41	14.85	10.00
12 1 82	12.82	12.29	13.14	25.86	13.61	10.99
12 2 82	11.08	10.00	10.65	21.25	13.61	10.99
12 3 82		11.39	13.14		18.54	10.99
12 6 82	13.69	10.00	13.14	18.95		15.66
12 7 82	15.44	11.39	14.39	22.41	14.85	10.99
12 8 82	10.00	11.39	18.12	18.95	16.08	
12 9 82	13.69	11.39	10.65	20.10	16.08	15.66
12 10 82		10.00				
12 13 82	10.20	14.08	13.14	21.25	21.01	15.66
12 14 82	13.69	10.00	11.78	17.80	16.08	15.66
12 15 82		12.29	15.48			17.99

RESULTS OF SELENIUM ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM FITCHBURG TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 5 82	10.00	15.41	17.42	10.00	10.00	10.00
10 6 82	10.00	10.00	17.42	10.00	10.00	10.00
10 7 82	14.48	10.00	10.00	10.00	10.00	10.00
10 8 82	12.38	10.00	10.00	10.00	10.00	
10 13 82	10.29	10.00	10.00	10.00	10.00	10.00
10 14 82	16.57	10.00	10.00	10.00	10.00	10.00
10 15 82	10.00	10.00	10.10	10.00	10.00	10.00
10 16 82	12.38	10.00	10.00	10.00	10.00	10.00
10 17 82	18.66	10.00	15.07	10.00	10.00	10.00
10 18 82	12.38	10.00	10.00	10.00	10.00	10.00
10 19 82	12.38	10.00	10.00	10.00		10.00
10 20 82	18.65	10.00	10.00	10.00	10.00	
10 21 82	10.00		10.00			10.00
10 22 82	11.73		10.00	10.00		10.00
10 23 82	10.00		10.00	10.00		10.00
10 24 82	10.00		10.00	10.00		10.00
10 25 82	10.00		10.00	10.00		10.00
10 26 82	10.00		10.00	10.00		10.00
10 27 82	10.00		10.00	10.00		10.00
10 28 82	10.00		10.00	10.00		10.00
10 29 82	22.70		10.00	10.00		10.00
10 30 82	10.00		10.00	10.06		10.00
10 31 82	10.00		10.00	10.00		10.00
11 1 82	10.00		10.00	10.06		10.00
11 2 82	10.00		10.00	10.00		10.00
11 3 82	14.79		10.00	10.00		10.00
11 4 82			10.00			10.00
11 5 82	12.15		10.00	10.00		10.00
11 6 82	20.06		10.00	10.00		10.00
11 7 82	10.00		10.00	10.00		10.00
11 8 82	12.15		10.00	10.00		10.00
11 9 82	10.00		14.18	10.00		10.00
11 10 82	10.00		10.15	10.00		10.00
11 11 82	10.00		10.00	10.00		10.00
11 12 82	10.00		10.00	10.00		10.00
11 13 82	10.00		10.00	10.00		10.00
11 14 82	10.00		10.00	10.00		10.00
11 15 82	10.00		10.00	10.00		10.00
11 16 82	10.00		10.00	10.00		10.00
11 17 82	10.00		10.00	10.00		10.00
11 18 82	10.00		10.00	10.00		10.00
11 19 82	10.00		10.00	10.00		10.00
11 20 82	10.00	18.16	10.00	10.00	10.00	10.00
11 21 82	10.00	10.04	10.00	10.00	10.00	10.00
11 22 82	10.00	10.00	10.00	10.00	10.00	10.00
11 27 82	10.00	10.00	10.00	10.00	10.00	10.00
11 28 82	10.00		10.00	10.00		10.00
11 29 82	10.00		10.00	10.00		10.00
11 30 82	10.00	10.00	10.00	10.00	10.00	10.00
12 1 82	11.08	10.00	10.00	10.00	10.00	10.00
12 2 82	10.00	10.00	10.00	10.00	10.00	10.00
12 3 82	10.00		10.00	10.00		10.00

RESULTS OF SELENIUM ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM PITTSFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
9 17 82	25.25		12.53	10.00		10.00
9 20 82	36.75		12.53	10.00		10.00
9 21 82	39.63		10.00	10.00		10.00
9 22 82	22.38		10.00	10.00		10.00
9 23 82				10.60		13.30
9 24 82	31.00		10.00	10.00		10.00
9 27 82	28.13		12.53	10.00		10.00
9 28 82	36.75		17.42	10.00		10.00
9 29 82	28.13		32.09	10.00		10.00
9 30 82	31.00		32.09	19.08		11.29
10 1 82	33.88		32.09	10.00		10.00
10 4 82	10.00		32.09	10.60		10.00
10 5 82	16.63		17.42	14.84		10.00
10 6 82	13.75		10.00	10.00		10.00
10 7 82	10.00		14.97	10.00		10.00
10 8 82	15.00	10.00	10.00	10.00	10.00	10.00
10 12 82	24.94	14.32	10.00	10.00	10.00	10.45
10 13 82	22.85	10.00	10.00	10.00	10.00	10.00
10 14 82	24.94	10.00	17.56	10.00	10.00	10.00
10 15 82	16.57	10.00	10.00	10.00	10.00	10.00
10 18 82	20.75	10.00	12.58	10.00	10.00	10.00
10 19 82	16.57	10.00	10.00	10.00	10.00	10.00
10 20 82	24.94	14.32	10.00	10.00	10.00	10.00
10 21 82		10.00	10.00	10.00	10.00	10.00
10 22 82	23.26	12.06	10.00	11.63	10.00	10.00
10 25 82	11.73	14.32	10.00	10.00	10.00	10.00
10 26 82	10.00	10.00	10.00	10.00	10.00	10.00
10 27 82	10.00	10.00	10.00	10.00	10.00	10.00
10 28 82	10.00	10.00	10.00	10.00	10.00	10.00
10 29 82	11.73	10.00	10.00	10.00	10.00	10.00
11 1 82	10.00	10.00	10.00	10.00	10.00	10.00
11 2 82	20.06	11.83	10.00	10.00	10.00	10.00
11 3 82	27.97	10.00	10.00	10.06	10.00	10.00
11 4 82	14.79	10.00	10.00	10.00	10.00	10.00
11 5 82	22.70	23.30	10.00	10.00	10.00	10.00
11 8 82		11.83	10.00	10.00	10.00	10.00
11 9 82	10.00	10.00	10.00	10.00	10.00	10.00
11 10 82	14.79	16.42	14.18	10.00	10.00	10.00
11 12 82	10.00	11.83	10.00	10.00	10.00	10.00
11 15 82	10.00	10.00	10.00	10.00	10.00	10.00

RESULTS OF SELENIUM ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM MEDFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 4 82			27.20			10.00
10 5 82	16.63		19.86	10.00		10.00
10 6 82	10.00		22.31	10.00		10.00
10 7 82	10.00		14.97	10.00		10.00
10 8 82	10.00		10.00	10.60		10.00
10 12 82	12.38		10.00	10.00		10.00
10 13 82			10.10			10.00
10 14 82	20.75		10.00	10.00		10.00
10 15 82	10.00		10.00	10.00		10.00
10 18 82	16.57		10.00	10.00		10.00
10 19 82	16.57		10.00	10.00		10.00
10 20 82	20.75		10.00	10.00		10.00
10 21 82	27.87		10.00	10.00		10.00
10 22 82	18.65		10.00	10.00		10.00
10 25 82	14.04			10.00		
10 26 82	10.00		10.00	10.00		10.00
10 27 82	10.00		10.00	10.00		10.00
10 28 82	10.00			10.00		10.00
10 29 82	10.00		10.00	10.00		10.00
11 1 82	10.00		10.00	10.00		10.00
11 2 82	10.00		10.00	10.00		10.00
11 3 82			10.00			10.00
11 4 82		10.00			10.00	
11 5 82	10.00	10.00	10.00	10.00		10.00
11 9 82	12.15	10.00		10.00	10.00	
11 10 82	25.33	11.83		10.00	10.00	
11 11 82	10.00	11.83	10.00	10.00	10.00	10.00
11 12 82	10.00	21.01	10.00	10.00	10.00	10.00
11 15 82	10.00	18.71	10.00	10.00	10.00	10.00
11 16 82	10.00	11.83	18.22	10.00	10.00	10.00
11 17 82	10.00	18.71	10.00	10.00	10.00	10.00
11 18 82	10.00	10.04	10.00	10.00	10.00	10.00
11 19 82	10.00	10.00	10.00	10.00	10.00	10.75
11 23 82	10.00	10.00	10.00	10.00	10.00	10.00
11 29 82	10.00	12.75	10.00	10.00	10.00	10.00
11 30 82	10.00	12.75	10.00	10.00	10.00	10.00
12 1 82	10.00	10.00	10.00	10.00	10.00	10.00
12 2 82	10.00	10.00	10.00	10.00	10.00	10.00
12 3 82		10.00	10.00		10.00	10.00
12 6 82	10.00	10.00	10.00	10.00	10.00	10.00
12 7 82	10.00	10.00	10.00	10.00	10.00	10.00
12 8 82	15.41	10.00	10.00	10.00	10.00	
12 9 82	11.08	10.00	10.00	10.00	10.00	10.00
12 10 82		10.00			10.00	
12 13 82	10.00	10.00	10.00	10.00	10.00	10.00
12 14 82	10.00	10.00	10.00	10.00	10.00	10.00
12 15 82		12.75	10.00			10.00

RESULTS OF ZINC ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM FITCHBURG TREATMENT PLANT

DATE	UNFILTERED			FILTERED		
	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 5 82	0.59	0.30	0.30	0.30	0.30	0.30
10 6 82	0.47	2.11	0.30	0.30	0.30	0.30
10 7 82	0.34	0.61	0.30	0.30	0.30	0.30
10 8 82	0.48	0.30	0.30	0.30	0.30	
10 13 82	0.30	0.30	0.30	0.30	0.30	0.30
10 14 82	0.30	0.61	0.30	0.30	0.30	0.30
10 15 82	0.34	0.30	0.30	0.30	0.30	0.30
10 16 82	0.30	0.30	0.30	0.30	0.30	0.30
10 17 82	0.30	0.30	0.30	0.30	0.30	0.30
10 18 82	0.30	0.39	0.30	0.30	0.30	0.30
10 19 82	1.49	0.39	0.30	0.30		0.30
10 20 82	1.92	0.62	0.30	0.30	0.30	
10 21 82	0.47		0.30			0.30
10 22 82	0.83		0.30	0.30		0.30
10 23 82	0.47		0.30	0.30		0.30
10 24 82	0.47		0.30	0.30		0.30
10 25 82	0.71		0.30	0.30		0.30
10 26 82	0.59		0.30	0.30		0.30
10 27 82	0.47		0.30	0.30		0.30
10 28 82	0.47		0.30	0.30		
10 29 82	0.30		0.30	0.30		0.30
10 30 82	0.30		0.30	0.30		0.30
10 31 82	0.30		0.30	0.30		0.30
11 1 82	0.68		0.30	0.30	0.30	0.30
11 2 82	0.68		0.30	0.30	0.30	0.30
11 3 82	0.82		0.30	0.30		0.30
11 4 82			0.30			0.30
11 5 82	1.10		0.30	0.30		0.30
11 6 82	0.30		0.30	0.30		0.30
11 7 82	0.68		0.30	0.30		0.30
11 8 82	0.30		0.30	0.30		0.30
11 9 82	0.30		0.30	0.30	0.30	0.30
11 10 82	5.48		0.30	0.30	0.30	0.30
11 11 82	0.54		0.30	0.30		0.30
11 12 82	0.30		0.30	0.30		0.30
11 13 82	0.30		0.30	0.30		0.30
11 14 82	0.30		0.30	0.30		0.30
11 15 82	0.30		0.30	0.30		0.30
11 16 82	0.30		0.30	0.30		0.30
11 17 82	0.30		0.30	0.30		0.30
11 18 82	0.34		0.30	0.30		0.30
11 19 82	0.34		0.30	0.30		0.30
11 20 82	0.30	0.42	0.30	0.30	0.30	0.30
11 21 82	0.34	0.35	0.30	0.30	0.30	0.30
11 22 82	0.30	0.35	0.30	0.30	0.30	0.30
11 27 82	0.30	0.30	0.30	0.30	0.30	0.30
11 28 82	0.30		0.30	0.30		0.30
11 29 82	0.30		0.30	0.30		0.30
11 30 82	0.30	0.30	0.30	0.30	0.30	0.30
12 1 82	0.30	0.30	0.30	0.30	0.30	0.30
12 2 82	0.30	0.30	0.30	0.30	0.30	0.30
12 3 82	0.30		0.30	0.30		0.30

RESULTS OF ZINC ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM PITTSFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
9 17 82	0.71		0.30	0.30		0.30
9 20 82	0.89		0.30	0.30		0.30
9 21 82	1.74		0.30	0.30		0.30
9 22 82	0.59		0.30	0.30		0.30
9 23 82				0.30		0.30
9 24 82	1.20		0.30	0.30		0.30
9 27 82	0.89		0.30	0.30		0.30
9 28 82	1.10		0.30	0.30		0.30
9 29 82	0.89		0.30	0.30		0.30
9 30 82	1.53		0.30	0.30		0.30
10 1 82	1.32		0.30	0.30		0.30
10 4 82	0.89		0.30	0.30		0.30
10 5 82	1.10		0.30	0.30		0.30
10 6 82	0.68		0.30	0.30		0.30
10 7 82	1.10		0.30	0.30		0.30
10 8 82	1.20	0.30	0.30	0.30	0.30	0.30
10 12 82	0.62	0.61	0.30	0.30	0.30	0.30
10 13 82	0.34	0.30	0.30	0.30	0.30	0.30
10 14 82	0.62	0.39	0.30	0.30	0.30	0.30
10 15 82	0.62	0.39	0.30	0.30	0.30	0.30
10 18 82	0.62		0.30	0.30	0.30	0.30
10 19 82	0.30	0.39	0.30	0.30	0.30	0.30
10 20 82	0.48	0.82	0.30	0.30	0.30	0.30
10 21 82		0.39	0.30	0.30	0.30	0.30
10 22 82	2.50	0.62	0.30	0.30	0.30	0.30
10 25 82	0.96	0.30	0.30	0.30	0.30	0.30
10 26 82	0.59	0.30	0.30	0.30	0.30	0.30
10 27 82	0.83	0.30	0.30	0.30	0.30	0.30
10 28 82	1.20	0.39	0.30	0.30	0.30	0.30
10 29 82	1.44	0.30	0.30	0.30	0.30	0.30
11 1 82	0.59	0.73	0.30	0.30	0.30	0.30
11 2 82	0.35	0.85	0.30	0.30	0.30	0.30
11 3 82	0.47	0.58	0.30	0.30		0.30
11 4 82	0.30	1.04	0.30	0.30	0.30	0.30
11 5 82	0.96	0.42	0.30	0.30	0.30	0.30
11 8 82	0.30	0.42	0.30	0.30	0.30	0.30
11 9 82	0.82	0.42	0.30	0.30	0.30	0.30
11 10 82	0.54	0.30	0.30	0.30	0.30	0.30
11 12 82	0.68	0.58	0.30	0.30	0.30	0.30
11 15 82	1.41	0.30	0.30	0.30	0.30	0.30

RESULTS OF ZINC ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM MEDFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 4 82			0.30	0.30		0.30
10 5 82	2.38		0.30			0.30
10 6 82	0.89		0.30	0.30		0.30
10 7 82	1.08		0.30	0.30		0.30
10 8 82	0.35		0.30			0.30
10 12 82	0.34		0.30	0.30		0.30
10 13 82			0.30			0.30
10 14 82	0.34		0.30	0.30		0.30
10 15 82	0.30		0.30	0.30		0.30
10 18 82	0.30		0.30	0.30		0.30
10 19 82	0.62		0.30	0.30		0.30
10 20 82	1.20		0.30	0.30		0.30
10 21 82	2.35		0.30	0.30		0.30
10 22 82	2.42		0.30			0.30
10 25 82	0.71					
10 26 82	0.96		0.30	0.30		0.30
10 27 82	0.83		0.30	0.30		0.30
10 28 82	0.96		0.30	0.30		0.30
10 29 82	0.83		0.30	0.30		0.30
11 1 82	0.30		0.30	0.30		0.30
11 2 82	0.47		0.30	0.30		0.30
11 3 82			0.30			0.30
11 4 82		0.30			0.30	
11 5 82	0.68	0.30	0.30	0.30		0.30
11 9 82	0.96	0.30		0.30	0.30	
11 10 82	1.79	0.30		0.30	0.30	
11 11 82	2.34	0.30	0.30	0.30	0.30	0.30
11 12 82	1.10	0.30	0.30	0.30	0.30	0.30
11 15 82	0.34	0.30	0.30	0.30	0.30	0.30
11 16 82	0.34	0.30	0.30	0.30	0.30	0.30
11 17 82	0.30	0.30	0.30	0.30	0.30	0.30
11 18 82	0.30	0.30	0.30	0.30	0.30	0.30
11 19 82	0.30	0.30	0.30	0.30	0.30	0.30
11 23 82	0.56	0.30	0.30	0.30	0.30	0.30
11 29 82	0.30	0.30	0.30	0.30	0.30	0.30
11 30 82	0.30	0.30	0.30	0.30	0.30	0.30
12 1 82	0.30	0.30	0.30	0.30	0.30	0.30
12 2 82	0.30	0.30	0.30	0.30	0.30	0.30
12 3 82	2.92	0.30	0.30		0.30	0.30
12 6 82	0.30	0.30	0.30	0.30		0.30
12 7 82	0.30	0.30	0.30	0.30	0.30	0.30
12 8 82	0.30	0.30	0.30	0.30	0.30	
12 9 82	0.30	0.30	0.30	0.30	0.30	0.30
12 10 82		0.30				
12 13 82	0.30	0.30	0.30	0.30	0.30	0.30
12 14 82	0.30	0.30	0.30	0.30	0.30	0.30
12 15 82		0.30	0.30			0.30

RESULTS OF ALUMINUM ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM FITCHBURG TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 5 82	2628.8	1600.8	524.8	233.2	136.2	
10 6 82	2732.8	6076.3	595.2	203.7	202.2	87.8
10 7 82	2083.0	3597.6	420.5	138.6	179.0	97.8
10 8 82	2902.0	1873.5	475.0	209.2	211.8	
10 13 82	1575.0	1184.4	432.4	217.0	172.2	89.8
10 14 82	2168.0	1093.5	832.5	164.7	178.2	73.9
10 15 82	1631.7	948.1	540.9	339.9	174.2	93.0
10 16 82	2506.7	690.6	420.9	326.8	281.2	102.6
10 17 82	824.3	569.4	601.0	269.3	172.2	45.2
10 18 82	661.9	524.0	901.1	211.8	138.2	59.6
10 19 82	1368.7	1509.9	676.7	193.5		84.0
10 20 82	1129.9	2937.4	556.6	94.0	120.2	
10 21 82	1082.2		548.1			123.1
10 22 82	3541.4		748.7	176.4		304.8
10 23 82	2779.4		806.9	157.6		78.7
10 24 82	1418.5		814.2	130.8		68.1
10 25 82	1776.6		959.7	130.8		30.8
10 26 82	2206.4		661.4	276.8		62.7
10 27 82	1824.4		824.1	385.5		78.7
10 28 82	1787.5		669.7	377.1		
10 29 82	1164.4		707.7	336.0		69.3
10 30 82	1082.8		691.0	144.2		76.3
10 31 82	797.2		695.2	260.0		85.2
11 1 82	2095.3		562.8	92.9		79.9
11 2 82	2043.3		532.8	117.5		62.0
11 3 82	5945.4		900.3	64.4		88.8
11 4 82			866.3			183.4
11 5 82	5785.3		380.3	102.4		232.6
11 6 82	1212.6		941.2			112.0
11 7 82	1446.2		926.3	178.2		128.1
11 8 82	572.7		528.3	132.7		119.2
11 9 82	2003.3		693.8	51.2		25.9
11 10 82	2346.7		611.3	155.4		20.0
11 11 82	3033.4		337.6	170.6		54.3
11 12 82	2651.9		423.5	99.3		92.5
11 13 82	1946.1		290.3	127.7		76.6
11 14 82	1335.7		263.9	182.7		55.3
11 15 82	1449.2		739.4	115.3		80.1
11 16 82	991.3		547.8	198.7		44.6
11 17 82	1202.1		448.8	85.1		41.1
11 18 82	1939.3		369.5	78.0		25.9
11 19 82	1703.4		336.5	79.8		85.0
11 20 82	2234.2	2280.3	435.0	86.9	179.0	99.2
11 21 82	2499.6	1615.6	237.4	106.4	176.8	115.1
11 22 82	1379.0	1472.2	250.7	172.1	123.2	67.3
11 27 82	1349.5	1352.6	328.1	177.0	161.2	104.5
11 28 82	494.5		214.1	139.0		175.4
11 29 82	317.4		595.1	111.4		99.2
11 30 82	1261.3	2021.9	872.1	145.9	212.5	134.6
12 1 82	995.9	372.8	877.3	142.4	185.7	141.7
12 2 82	3871.6	564.0	607.7	118.3	223.7	83.2
12 3 82	2161.2		391.9	142.4		63.7

RESULTS OF ALUMINUM ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM PITTSFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
9 17 82	26453.0		520.2	601.3		137.1
9 20 82	16040.0		941.1	282.7		108.1
9 21 82	13856.0		956.8	316.8		112.4
9 22 82	20188.0		1082.0	388.9		125.5
9 23 82				381.9		291.9
9 24 82	14046.0		1093.1	488.1		166.1
9 27 82	45325.0		1082.0	233.2		105.2
9 28 82	36214.0		1113.3	318.1		134.2
9 29 82	29706.0		1207.2	714.6		160.3
9 30 82	25477.0		800.3	523.0		223.0
10 1 82	27429.0		1113.3	573.0		219.4
10 4 82	26453.0		790.7	438.5		281.0
10 5 82	23199.0		1094.6	325.2		177.7
10 6 82	18969.0		1016.4	473.9		128.4
10 7 82	21990.0		903.8	417.3		115.3
10 8 82	21339.0	1888.7	859.9	410.2	349.0	118.2
10 12 82	12987.0	1858.4	1128.5	243.2	231.2	166.2
10 13 82	17574.0	3271.4	1843.1	483.8	425.6	112.1
10 14 82	10870.0	3075.0	1592.6	601.4	320.6	83.4
10 15 82	9812.0	1084.7	1245.4	385.7	405.7	320.1
10 18 82	8400.0	1251.4	1434.0	268.0	160.6	102.6
10 19 82	33098.0	2339.0	885.2	411.8	205.6	142.6
10 20 82	5577.7	2763.2	1146.6	457.6	285.6	131.9
10 21 82		2719.8	1115.3	260.0	295.6	85.8
10 22 82	12333.0	1756.8	1578.3	276.8	285.6	75.2
10 25 82	19496.0	1088.6	1270.9	293.5	165.6	128.4
10 26 82	11069.0	1344.6	1270.9	268.4	226.0	61.0
10 27 82	22209.0	1312.6	1169.0	122.4	217.7	124.8
10 28 82	10472.0	1441.0	902.5	189.3	316.2	57.1
10 29 82	22709.0	1785.6	771.6	243.3	299.8	131.8
11 1 82	11786.0	963.7	1309.9	144.2	287.5	83.5
11 2 82	12146.0	478.0	1377.5	104.0	283.4	149.5
11 3 82	11237.0	2992.0	719.8	494.3	365.5	169.1
11 4 82	8485.4	1657.0	382.8	170.5	369.8	92.4
11 5 82	9486.5	1673.1	510.2	341.2	484.5	209.8
11 8 82	2666.4	1111.3	619.3		386.0	122.7
11 9 82	12309.0	1560.7	679.3	426.5	439.3	58.8
11 10 82	8255.7	1753.3	581.3	758.3	566.8	62.4
11 12 82	18508.6	1223.7	1579.2	305.9	353.2	67.7
11 15 82	19463.0	1102.1	407.2	137.2	316.2	131.6

RESULTS OF ALUMINUM ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM MEDFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 4 82			149.7			132.3
10 5 82	1978.8		83.9			66.1
10 6 82	3458.8		159.0	240.5		76.2
10 7 82	1343.0		87.1	130.1		72.4
10 8 82	1186.0		124.4			83.2
10 12 82	1999.0		72.0	219.6		62.9
10 13 82			134.4			128.0
10 14 82	2733.0		42.1	136.0		44.1
10 15 82	559.1		82.6	167.3		70.8
10 18 82	530.9		44.8	112.4		53.5
10 19 82	700.3		55.0	102.0		56.6
10 20 82	747.9		130.8	149.0		66.1
10 21 82	1177.7		149.4	403.0		103.5
10 22 82	1488.1		108.0			92.9
10 25 82	1681.1			152.5		
10 26 82	2278.0		88.0	130.8		85.8
10 27 82	1848.2		98.5	127.4		62.9
10 28 82	1787.5		20.0	78.9		59.7
10 29 82	1865.4		96.4	77.2		88.2
11 1 82	1134.7		112.9	142.5		105.2
11 2 82	2406.8		86.1	72.0		63.5
11 3 82			61.8			55.2
11 4 82		790.3			353.2	
11 5 82	1316.4	405.1	180.3	91.0		350.0
11 9 82	1850.7	1303.9		216.1	187.2	
11 10 82	2346.7	437.2		155.4	143.3	
11 11 82	5914.5	199.8	135.5	102.3	133.1	77.4
11 12 82	4150.0	149.1	58.9	203.2	154.4	40.1
11 15 82	1183.1	195.4	80.4	207.6		79.1
11 16 82	1468.2	319.1	91.1	184.4	165.6	69.5
11 17 82	1469.2	223.7	71.2	86.9	181.3	44.6
11 18 82	1113.6	170.7	48.8	85.1	96.4	39.3
11 19 82	1585.5	140.9	29.0	46.0	40.0	26.7
11 23 82	1762.4	140.9	78.8	125.9	87.5	89.3
11 29 82	1703.4	112.2	103.8	176.6	60.6	79.7
11 30 82	1349.5	95.5	98.8	111.4	196.9	67.3
12 1 82	1408.5	207.8	134.2	204.6	132.1	70.0
12 2 82	2692.0	152.8	105.4	76.9	154.5	77.9
12 3 82	12080.0	203.6	65.1		85.2	55.8
12 6 82	2456.1	100.3	40.5	90.7		40.7
12 7 82	2338.1	140.9	58.1	70.0	132.1	48.7
12 8 82	3517.7	291.1	112.9	94.1	118.7	
12 9 82	2456.1	117.0	53.1	109.7	152.2	76.2
12 10 82		131.3				
12 13 82	1276.5	126.5	50.6	83.8	123.2	60.2
12 14 82	981.6	97.9	44.7	42.4	60.6	104.5
12 15 82		78.7	78.4			150.6

RESULTS OF TOC ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM FITCHBURG TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 5 82	36.10	74.56	3.44	34.87	28.78	4.31
10 6 82	12.14	66.08	3.77	16.17	27.82	6.37
10 7 82	50.33	44.65	8.01	34.17	37.65	13.91
10 8 82	72.95	72.37	7.52	55.25	35.69	6.44
10 13 82	34.48	60.63	5.49	41.19	35.69	13.33
10 14 82	38.12	57.69	8.01	35.19	41.56	11.01
10 15 82	52.92	34.22	9.20	30.64	23.16	10.20
10 16 82	36.93	42.89	9.30	21.98	36.10	16.78
10 17 82	56.87		9.30	34.72	33.55	18.82
10 18 82	32.49	59.65	9.87	35.27	35.73	14.85
10 19 82	28.06	25.55	8.50	23.64	26.99	13.20
10 20 82	31.80	35.43	9.70	30.45		30.45
10 21 82	10.33		10.00	28.00		
10 22 82	40.92		11.80	36.63		19.10
10 23 82	32.33		15.60	28.31		13.60
10 24 82	63.47		9.20	36.97		14.60
10 25 82	76.13		8.80	36.99		12.50
10 26 82	75.87		10.07	29.04		7.54
10 27 82	69.51		12.71	27.98		6.93
10 28 82	35.55		7.15	24.01		11.11
10 29 82	29.65		8.28	24.82		9.07
10 30 82	35.59		9.57	20.56		8.04
10 31 82	44.07		9.26	26.92		8.30
11 1 82	61.53	70.41	8.55	20.97	14.33	7.95
11 2 82	55.31	26.36	8.35	31.45	17.06	7.95
11 3 82	156.89		9.06	30.27		8.15
11 4 82			11.76			13.34
11 5 82	82.74		11.45	37.60		11.76
11 6 82	56.09		7.82	26.32		8.88
11 7 82	49.94		13.03	30.93		7.95
11 8 82	60.19		7.12	29.40		8.05
11 9 82	64.29	16.86	7.98	29.91	12.55	7.45
11 10 82	56.09	34.35	9.35	38.62	28.25	10.09
11 11 82	106.19		16.03	43.50		15.29
11 12 82	72.27		8.61	40.86		17.30
11 13 82	27.75		9.66	33.44		16.24
11 14 82	10.87		7.23	21.06		13.38
11 15 82	51.07		7.44	20.72		10.04
11 16 82	15.04		9.82	30.26		9.92
11 17 82	15.04		8.10	15.42		12.30
11 18 82	31.53		8.21	15.96		9.16
11 19 82	39.49		10.89	18.27		10.13
11 20 82	35.29	46.36	9.01	24.05	22.50	8.47
11 21 82	33.19	58.14	7.33	23.52	18.00	8.62
11 22 82	49.99	35.99	5.71	23.00	23.00	9.27
11 27 82	45.79	25.72	6.73	27.20	27.00	6.30
11 28 82	39.49		7.53	20.90		7.53
11 29 82	52.09		7.60	29.30		7.96
11 30 82	39.49	67.99		17.75	24.00	7.64
12 1 82	49.99		13.82	25.10	20.50	8.74
12 2 82	37.39	34.32	12.07	36.65	21.72	16.56
12 3 82	43.69		11.00	30.27		15.97

RESULTS OF TOC ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM PITTSFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
9 17 82	96.77		17.37	51.34		16.11
9 20 82	39.14		14.69	13.28		
9 21 82	52.44		12.31	32.50		13.20
9 22 82	70.17		14.19	54.11		15.64
9 23 82	155.23		14.05	91.37		11.25
9 24 82	55.02		12.50	17.70		11.60
9 27 82	62.75		9.71	37.66		9.71
9 28 82	85.29		11.79	43.43		10.81
9 29 82	101.74		16.64	59.70		15.04
9 30 82	97.62		20.36	56.64		18.29
10 1 82	96.77		19.44	64.64		16.41
10 4 82	41.74		13.69	17.32		13.36
10 5 82	25.31		6.74	16.88		9.79
10 6 82	63.64		5.97	24.54		10.01
10 7 82	103.79		14.97	31.58		20.28
10 8 82	103.67		17.87	73.22		21.95
10 12 82	89.40	90.95	9.52	67.08	72.38	12.62
10 13 82	68.83	101.71	13.62	56.28	72.38	16.03
10 14 82	173.71	119.32	13.59	73.25	96.34	17.87
10 15 82	111.71	95.79	18.27	23.57	83.17	
10 18 82	63.30	53.97	16.04	34.70	40.11	15.95
10 19 82	133.09	38.60	14.80	59.65	41.20	15.00
10 20 82	164.74	122.99	20.00	117.66	109.52	25.70
10 21 82	143.64	57.29	24.00	74.94	95.53	21.60
10 22 82	121.15	96.60	21.27	86.55	104.20	25.30
10 25 82	177.40	81.17		34.72	51.35	15.90
10 26 82	177.62	93.06	11.90	57.65	97.37	
10 27 82	162.78	173.13	18.69	100.27	68.47	15.75
10 28 82	83.47	121.75	21.48	89.58	102.97	21.70
10 29 82	103.42	93.26	23.29	92.90	84.56	24.08
11 1 82	99.19	87.04	17.37	48.11	65.04	16.26
11 2 82	137.34		13.42	50.49	34.64	12.10
11 3 82	121.65	112.47	18.99	70.72	70.17	16.56
11 4 82	100.91	93.87	18.38	58.40	69.92	
11 5 82	165.18	106.97	16.76	82.18	80.47	15.29
11 8 82	72.49	58.00	14.03	29.40	36.69	12.27
11 9 82	113.49	69.30	13.80	63.73	50.41	11.78
11 10 82	119.64	115.66	22.91	97.55	101.79	19.20
11 12 82	172.93	114.53	27.48	103.19	88.91	23.45
11 15 82	57.43	68.11	14.43	42.44	50.41	17.41

RESULTS OF TOC ANALYSES OF 24-HR COMPOSITE SAMPLES
FROM MEDFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 4 82			6.88			8.43
10 5 82	51.47		3.75	56.06		8.17
10 6 82	47.48		2.30	20.47		1.48
10 7 82	83.23		14.36	46.51		18.56
10 8 82	120.25		7.23	44.46		14.78
10 12 82	63.46		3.91	41.46		8.49
10 13 82			4.96			7.72
10 14 82	77.06		3.90	29.03		11.20
10 15 82	80.72		5.10	37.13		9.17
10 18 82	74.92		5.10	36.97		12.70
10 19 82	62.69		6.50	12.17		11.30
10 20 82	93.01		6.10	22.72		13.30
10 21 82	67.96		6.00			14.70
10 22 82	52.44		5.70	26.41		11.70
10 25 82	32.49			32.75		
10 26 82	122.51		5.31	31.16		6.33
10 27 82	52.55		5.31	27.45		7.04
10 28 82	41.36		5.67	29.73		9.53
10 29 82	44.54		8.05	37.92		8.73
11 1 82	128.87		7.54	64.01		2.12
11 2 82	105.06		8.96	20.97		9.67
11 3 82			6.93			3.28
11 4 82		5.87			4.52	
11 5 82	82.51	6.48	8.36	38.11	9.50	9.50
11 9 82	64.29	4.92		27.35	7.56	
11 10 82	191.38	4.86		26.32	7.24	
11 11 82	199.58	6.32	7.98	50.92	9.39	12.74
11 12 82	116.79	5.87	6.70	26.02	4.95	13.56
11 15 82	22.40	8.26	9.22	26.97	12.95	8.49
11 16 82	19.45	6.43	5.81	21.06	12.52	10.24
11 17 82	57.43	5.56	6.57	15.42	7.88	10.04
11 18 82	15.16	4.92	5.69	16.48	11.49	11.56
11 19 82	25.63	8.74	5.16	13.30	9.77	12.52
11 23 82	44.71	6.05	6.45	20.90	7.40	8.29
11 29 82	100.39	5.35	5.97	20.37	4.50	7.75
11 30 82	89.89	3.00	6.45	27.20	4.50	7.31
12 1 82	49.99	3.00	7.53	25.62	5.50	7.69
12 2 82	47.89	4.30	6.80	24.57	7.08	11.47
12 3 82		3.00	7.78		3.00	12.66
12 6 82	48.21	6.64	7.82	26.52	18.02	11.66
12 7 82	43.92	5.99	5.59	20.09	15.27	14.62
12 8 82	16.91	5.62	11.18	42.59	12.36	9.96
12 9 82	46.07	5.19	8.17	24.38	6.37	11.88
12 10 82		5.56			7.88	
12 13 82	28.92	5.89		19.02	11.76	12.46
12 14 82	67.50	5.40	7.41	18.48	3.00	9.33
12 15 82	21.96	6.32	5.75	22.49	10.85	13.73

RESULTS OF PHOSPHORUS ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM FITCHBURG TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 5 82	4.82	6.99	0.77	2.29	3.77	0.12
10 6 82	3.47	3.42	0.75	4.39	6.10	1.16
10 7 82	3.97	5.01	0.57	4.43	3.62	0.34
10 8 82	4.49	4.61	0.69	2.47	3.12	0.52
10 13 82	7.11	4.25	0.50	2.46	2.11	0.16
10 14 82	1.21	2.60	0.23	4.61	3.27	9
10 15 82	3.80	3.70	0.34	2.72	2.30	0.27
10 16 82	3.63	4.68	0.34	4.15	2.22	
10 17 82	8.60	3.08	0.19	3.67	1.24	
10 18 82	7.41	5.09	0.93	3.83	1.73	
10 19 82	4.68	1.99	0.39	3.15	2.74	0.11
10 20 82	3.36	4.68	0.48	2.94		0.22
10 21 82	2.97		0.58	2.24		0.15
10 22 82	4.97		0.49	2.73		0.20
10 23 82	5.24		0.41	2.86		0.37
10 24 82	4.13		0.56	2.94		0.27
10 25 82	4.66		0.53	2.75		0.13
10 26 82	3.51		0.59	2.25		0.27
10 27 82	3.51		0.64	2.86		0.46
10 28 82	2.61		0.61	1.87		0.47
10 29 82	2.96		0.84	1.76		0.74
10 30 82	4.40		1.43	2.95		1.09
10 31 82	3.33		1.57	2.95		1.35
11 1 82	5.08	3.11	1.93	3.43	3.03	1.57
11 2 82	5.17	2.43	2.02	2.85	1.02	1.96
11 3 82	8.28		2.44	2.75		1.88
11 4 82			2.20			1.91
11 5 82	3.31		2.07	2.12		1.51
11 6 82	28.26		2.35	32.56		2.66
11 7 82	5.95		3.85	4.08		2.85
11 8 82	3.53		1.63	3.38		2.01
11 9 82	3.85	2.24	2.72	1.86	0.87	2.69
11 10 82	3.18	3.03	2.57	2.75	0.80	2.44
11 11 82	6.86		2.03	2.73		1.87
11 12 82	4.68		1.35	1.99		1.29
11 13 82	3.28		1.95	3.12		1.64
11 14 82	2.50		1.29	1.57		0.92
11 15 82	2.58		1.83	1.60		0.96
11 16 82	2.07		1.58	1.64		1.57
11 17 82	2.67		2.04	2.97		1.64
11 18 82	4.69		1.79	4.60		1.59
11 19 82	3.94		2.39	2.06		1.70
11 20 82	5.46	4.37	2.43		4.52	1.31
11 21 82	3.83	4.62	2.17	2.84	4.43	1.74
11 22 82	3.92	5.48	1.44	2.30	4.52	0.84
11 27 82	2.58	4.20	1.18	2.28	3.26	0.99
11 28 82	2.54		1.33	2.02		1.07
11 29 82	2.11		1.68	1.94		1.03
11 30 82	1.91	2.88	3.21	1.14	2.15	1.60
12 1 82	2.23	2.24	1.50	1.83	0.96	1.52
12 2 82	4.52	4.11	2.00	2.39	3.52	1.76
12 3 82	4.02		1.88	1.38		2.25

RESULTS OF PHOSPHORUS ANALYSES OF 24-HR COMPOSITE SAMPLES FROM PITTSFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
9 17 82	9.22		0.87	3.00		0.75
9 20 82	6.27		0.64	2.22		0.41
9 21 82	6.27		0.66	1.57		0.31
9 22 82	4.61		0.70	1.34		0.35
9 23 82						
9 24 82	7.01		0.78	2.93		0.45
9 27 82	7.75		1.06	4.82		0.39
9 28 82	6.19		0.41	1.80		0.23
9 29 82	7.10		0.50	1.94		0.28
9 30 82	8.30		1.25	1.99		0.91
10 1 82	6.55		1.13	3.35		0.79
10 4 82			0.95	3.57		0.90
10 5 82	7.63		1.64	2.03		0.97
10 6 82	8.43		0.97	2.06		1.20
10 7 82	6.45		1.67	2.08		1.20
10 8 82	6.73	4.71	1.27	2.86	3.52	1.21
10 12 82	6.55	4.71	2.00	2.73	3.32	1.40
10 13 92	6.21	3.71	2.03	2.64	2.29	2.04
10 14 82	6.66	7.64	3.11	3.04	2.96	2.44
10 15 82	4.58	4.21	1.70	1.13	2.42	1.84
10 18 82	5.53	4.80	2.94	2.68	3.50	2.18
10 19 82	6.11	4.44	3.19	4.70	2.28	2.27
10 20 82	4.91	2.78	2.94	3.77	2.94	2.43
10 21 82	6.26	3.86	2.06	2.69	2.07	1.69
10 22 82	7.42	3.86	1.84	3.28	2.99	1.98
10 25 82	5.35	3.68	2.04	2.28	2.77	2.08
10 26 82	4.89	4.40	2.04	2.71	3.09	1.67
10 27 82	6.58	4.50	2.00	2.78	3.61	2.04
10 28 82	5.34	4.59	2.30	2.42	4.11	2.04
10 29 82	7.45	4.01		2.50	2.75	1.88
11 1 82	5.03	3.45	2.18	1.79	2.73	1.92
11 2 82	4.50	4.02	2.49	2.19	2.24	1.96
11 3 82	5.95	3.68	2.30	2.73	2.09	1.72
11 4 82	4.21	3.03	2.63	1.94	2.28	2.39
11 5 82	6.65	3.76	2.39	2.12	2.09	2.11
11 8 82	5.09	4.06	2.01	2.17	2.20	2.07
11 9 82	4.94	3.53	2.63	2.13	2.73	2.38
11 10 82	5.33	2.96	2.66	2.68	2.92	2.32
11 12 82	4.31	3.98	2.72	2.09	2.66	2.15
11 15 82	4.91	4.37	2.46	2.50	3.00	2.50

RESULTS OF PHOSPHORUS ANALYSES OF 24-HR COMPOSITE SAMPLES

FROM MEDFIELD TREATMENT PLANT

	UNFILTERED			FILTERED		
DATE	INFLUENT	PRIM.EFF	EFFLUENT	INFLUENT	PRIM.EFF	EFFLUENT
10 4 82			0.63			0.19
10 5 82	6.93		0.60	5.31		0.48
10 6 82	5.45		1.23	4.94		0.69
10 7 82	5.90		1.09	3.78		0.91
10 8 82	6.36		0.66	4.89		0.40
10 12 82	7.28		0.50	4.89		0.48
10 13 82			0.54			0.29
10 14 82	7.73		0.47	4.96		0.54
10 15 82	6.22		0.47	4.06		0.43
10 18 82	5.35		0.24	4.58		0.31
10 19 82	4.68		0.81	3.61		0.30
10 20 92	5.43		0.75	4.27		0.73
10 21 82	6.51		0.61	2.90		0.62
10 22 82	5.35		0.58	2.00		0.45
10 25 82	6.04			5.20		
10 26 82	4.97		0.47	4.59		0.53
10 27 82	4.74		0.50	3.51		0.37
10 28 82	4.17		0.46	3.04		0.42
10 29 82	4.80		0.85	2.96		0.87
11 1 82	5.47		0.51	3.43		0.43
11 2 82	5.08		0.52	3.48		0.49
11 3 82			0.51			0.33
11 4 82		0.49	0.38		0.53	2.12
11 5 82	5.64	0.76	0.45	3.81	0.42	0.31
11 9 82	5.02	0.68		3.22	0.42	
11 10 82	5.17	0.61		4.24	0.42	
11 11 82	7.95	0.64	0.39	4.84	0.95	0.48
11 12 82	4.60	0.53	0.43	3.36	0.72	0.37
11 15 82	4.99	1.47	0.51	4.21	1.47	0.42
11 16 82	3.36	0.96	0.67	2.42	0.78	0.51
11 17 82	2.66	1.38	1.25	2.42	1.21	0.88
11 18 82	3.01	1.51	2.00	1.85	2.19	1.27
11 19 82	7.10	1.94	1.87	2.37	2.66	2.52
11 23 82	4.86	4.03	3.03	2.71	4.60	2.65
11 29 82	5.72	3.86	3.03	3.40	5.05	2.60
11 30 82	4.60	3.43	3.38	2.39	4.88	2.69
12 1 82	3.60	3.69	3.01	2.15	4.20	3.09
12 2 82	4.43	6.07	2.81	4.25	3.94	2.53
12 3 82		3.70	3.01		5.31	3.01
12 6 82	3.84	5.14	2.69	3.04	3.77	2.93
12 7 82	3.44	4.11	3.09	2.27	4.45	3.21
12 8 82	2.96	3.17	3.38	2.67	4.11	3.17
12 9 82	4.33	3.17	1.84	2.35	3.69	2.03
12 10 82		3.26			3.60	
12 13 82	3.68	3.13	2.26	3.28	3.52	2.22
12 14 82	3.28	2.96	2.33	2.71	3.26	2.60
12 15 82	5.14	3.00	2.52	2.59	3.43	2.90

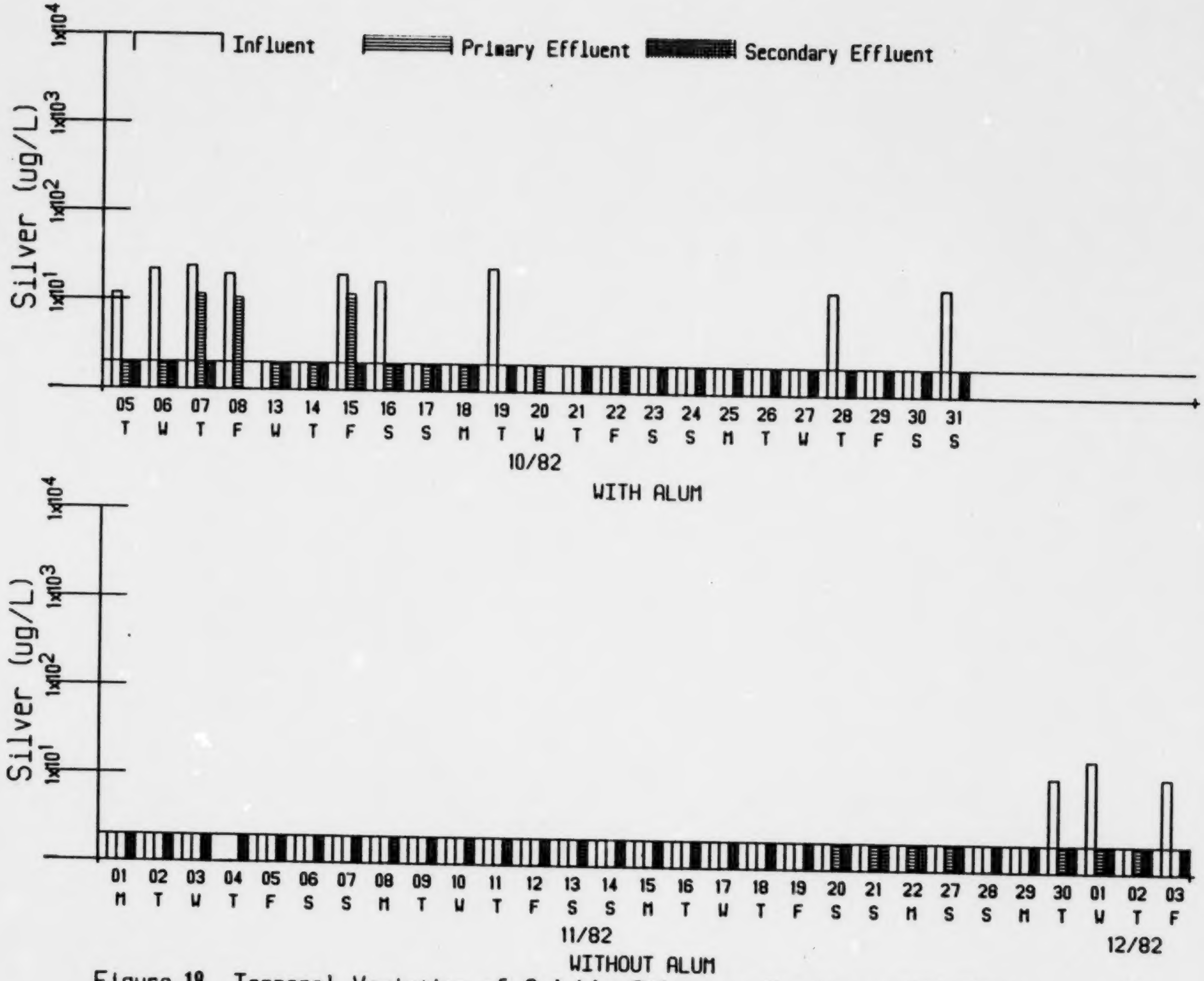


Figure 18 Temporal Variation of Soluble Silver at Fitchburg (MA) POTW

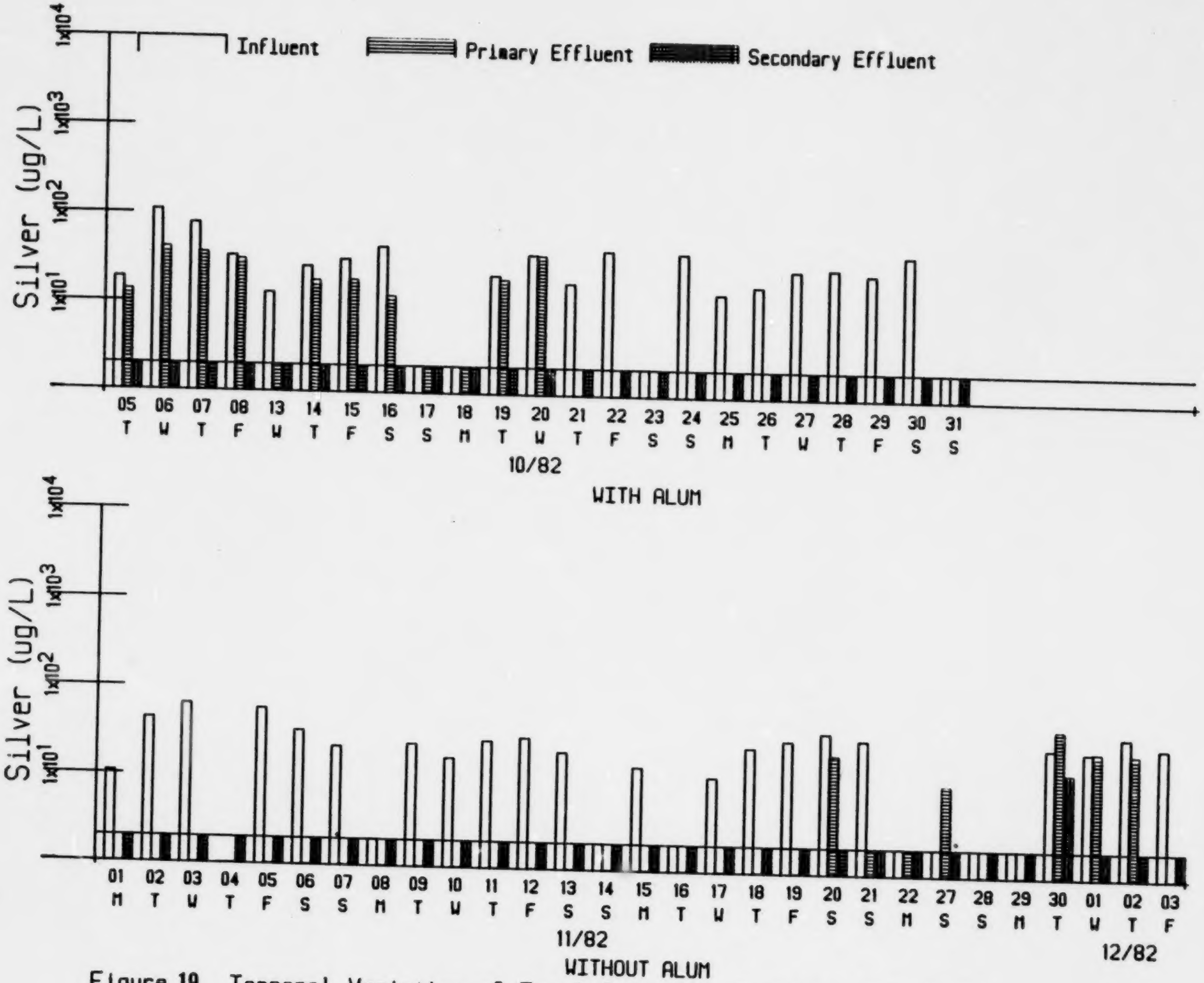


Figure 19 Temporal Variation of Total Silver at Fitchburg (MA) POTW

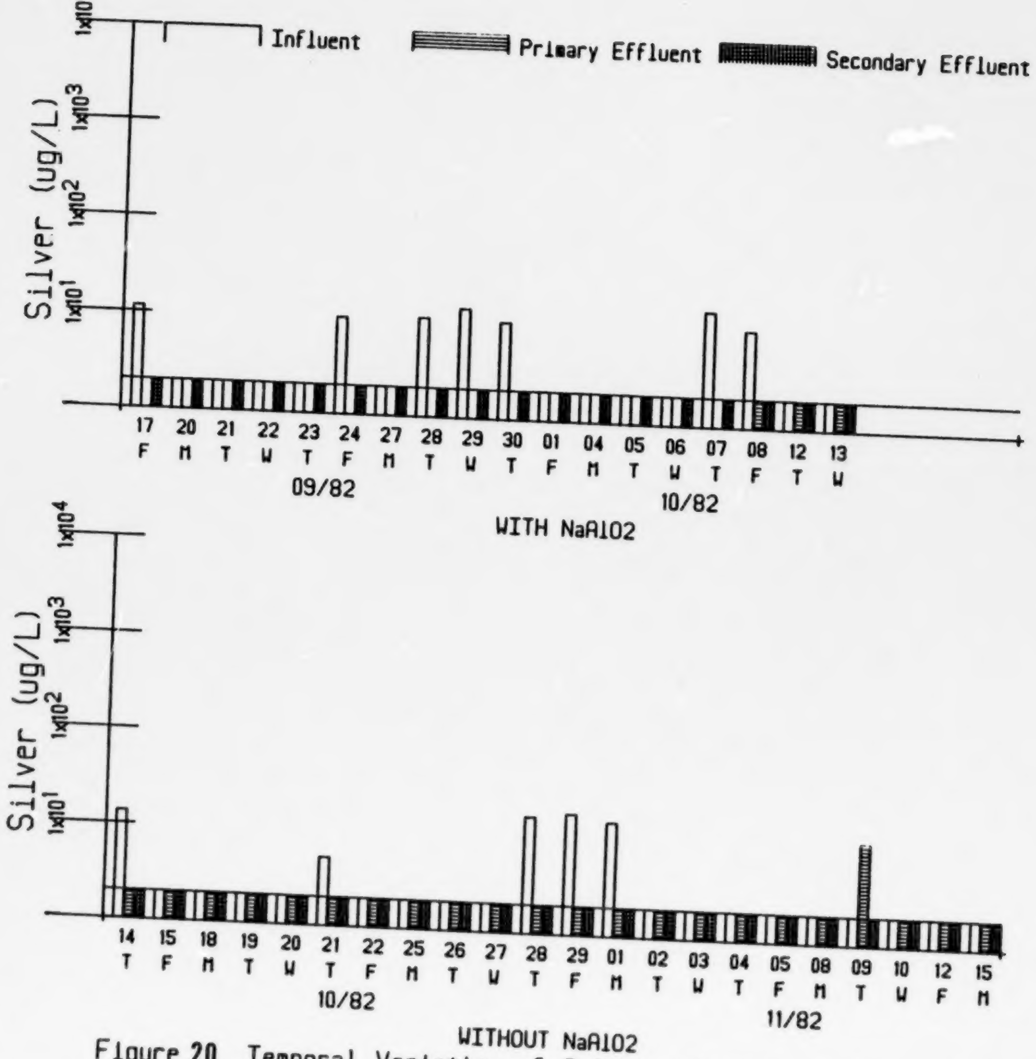


Figure 20 Temporal Variation of Soluble Silver at Pittsfield (MA) POTW

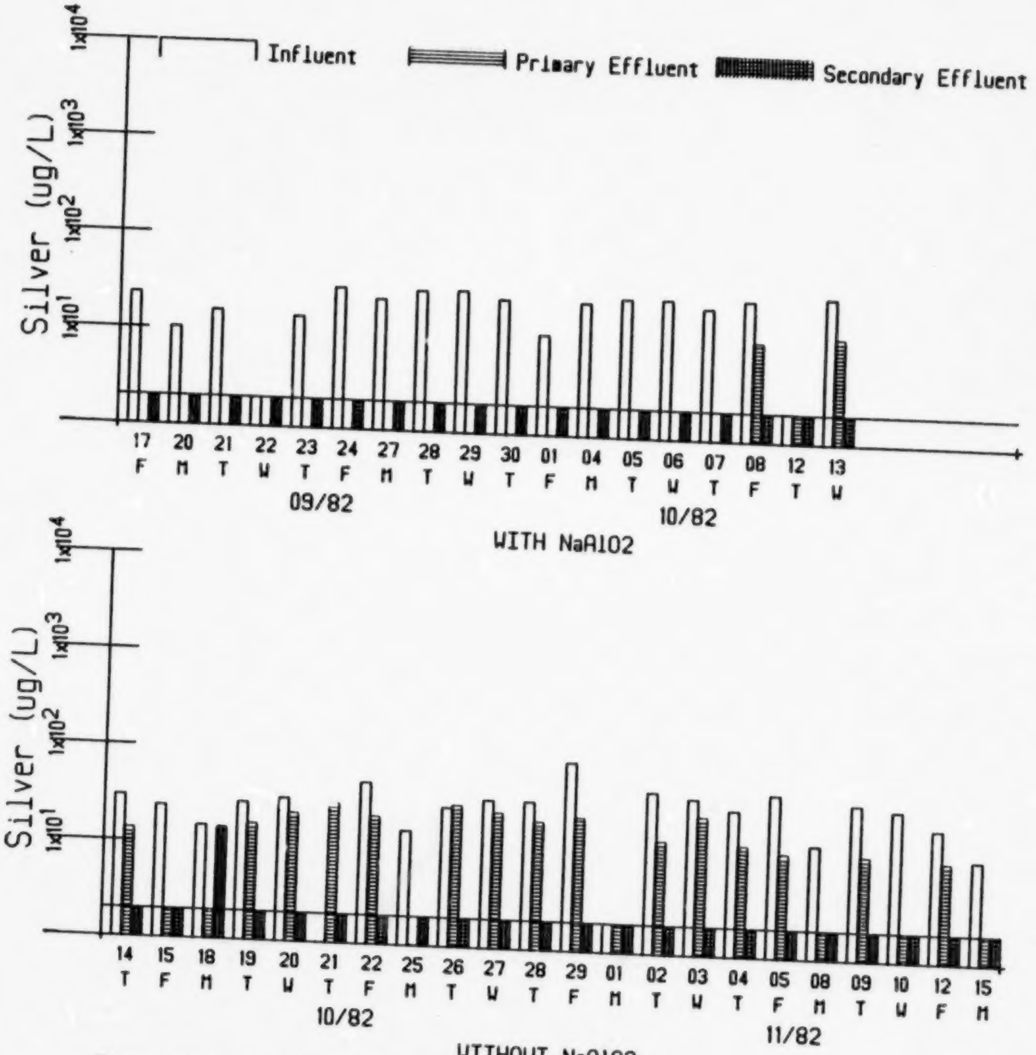


Figure 21 Temporal Variation of Total Silver at Pittsfield (MA) POTW

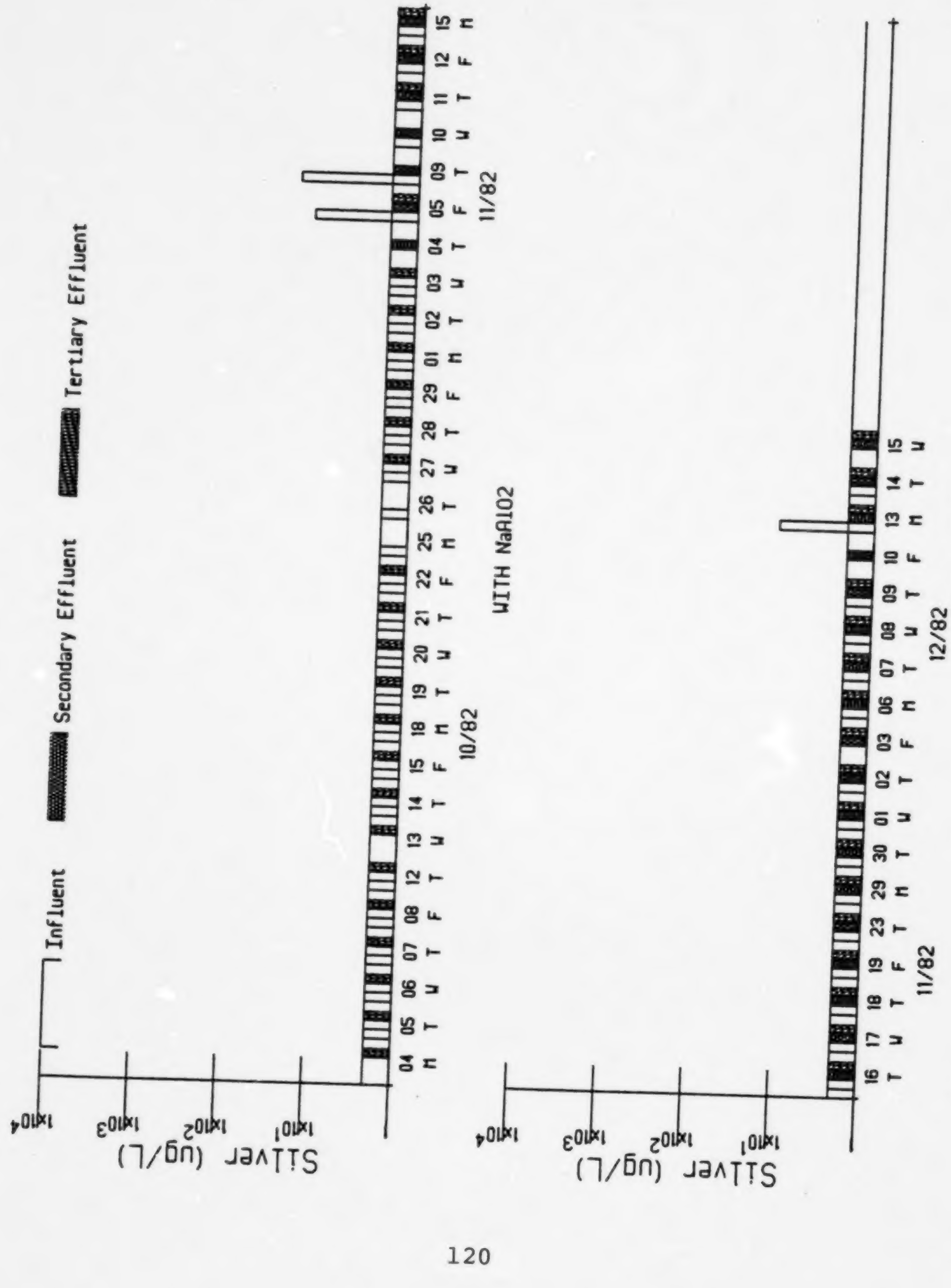


Figure 22 Temporal Variation of Soluble Silver at Medfield (MA) POTW

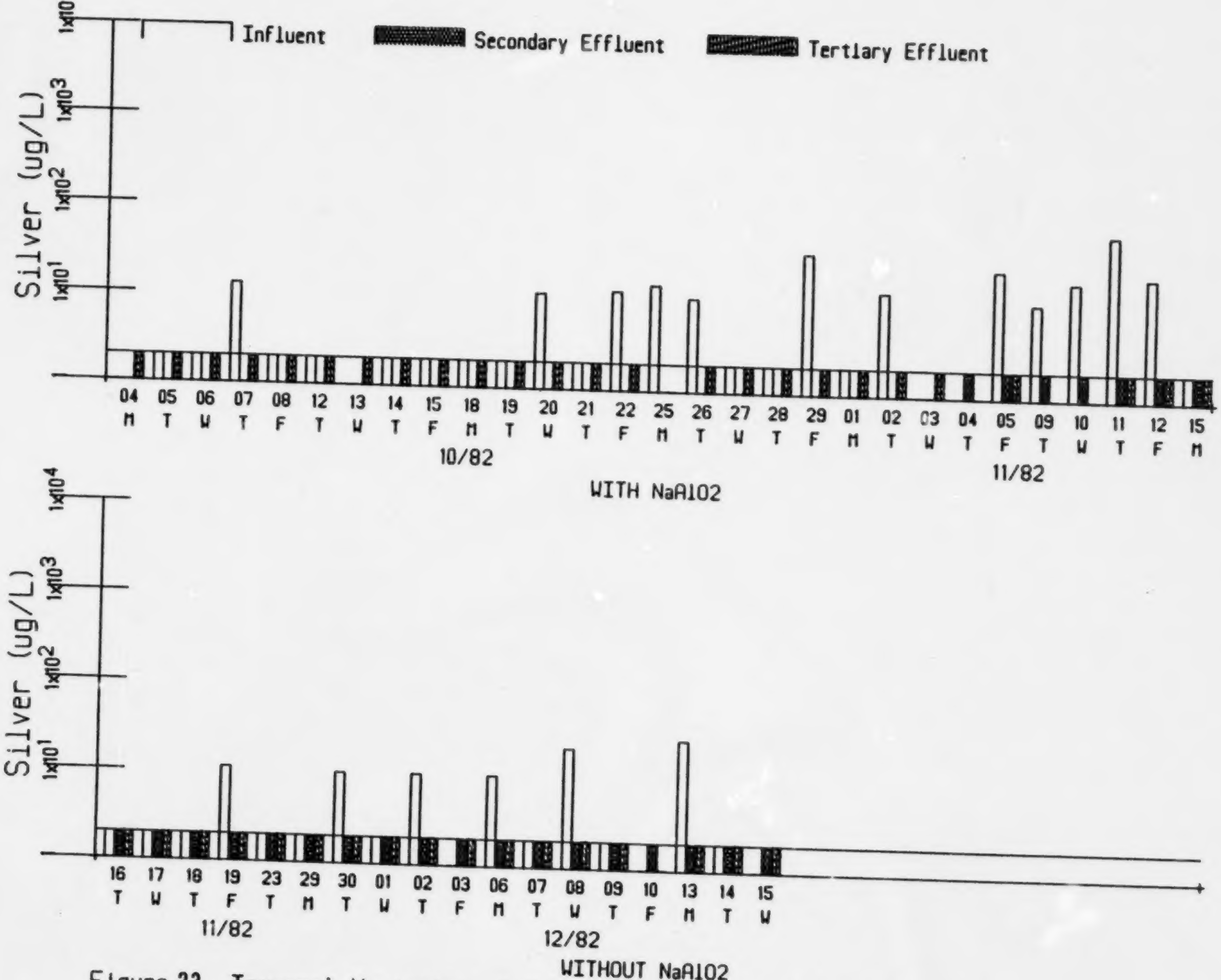


Figure 23 Temporal Variation of Total Silver at Medfield (MA) POTW

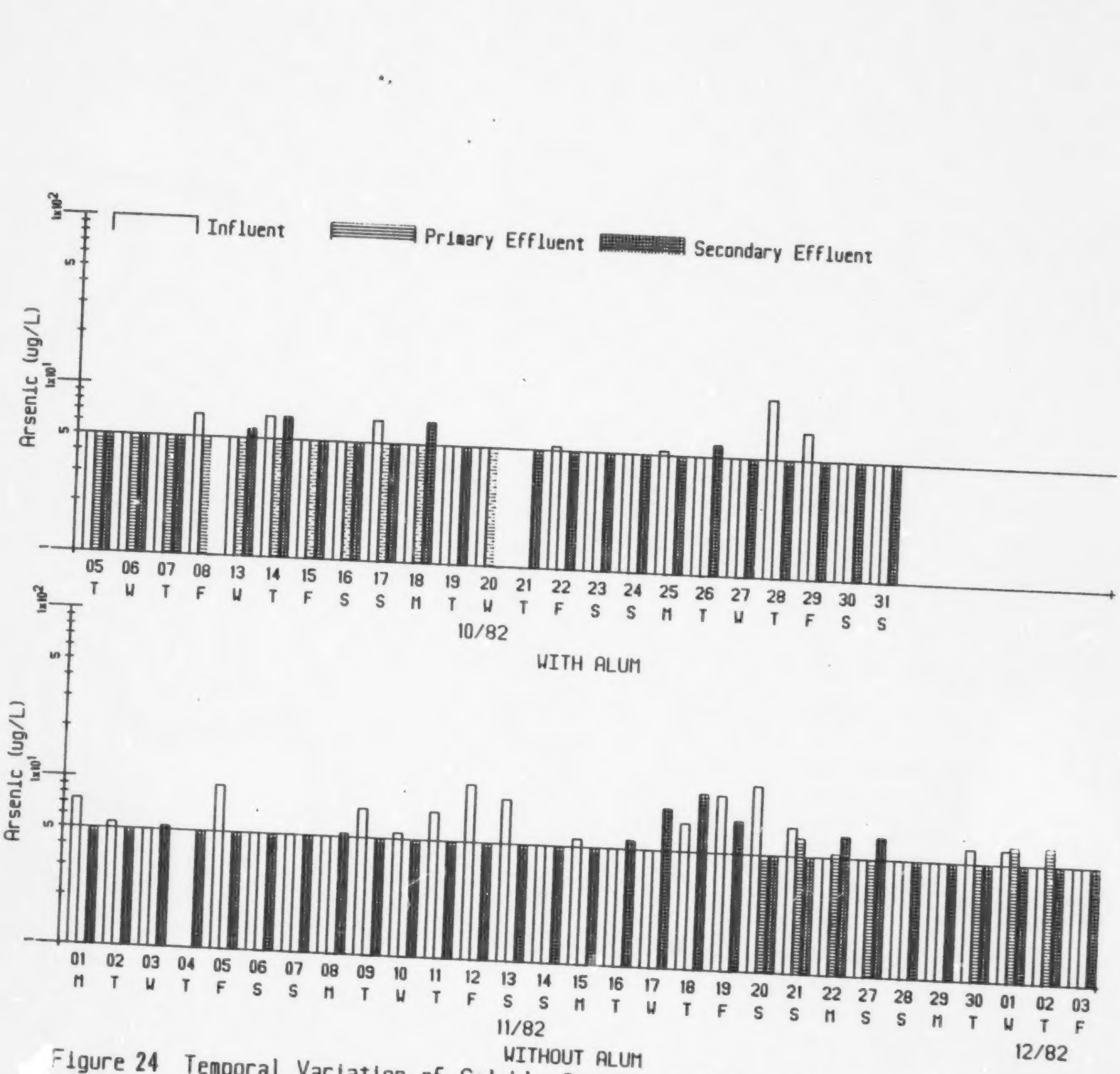


Figure 24 Temporal Variation of Soluble Arsenic at Fitchburg (MA) POTW

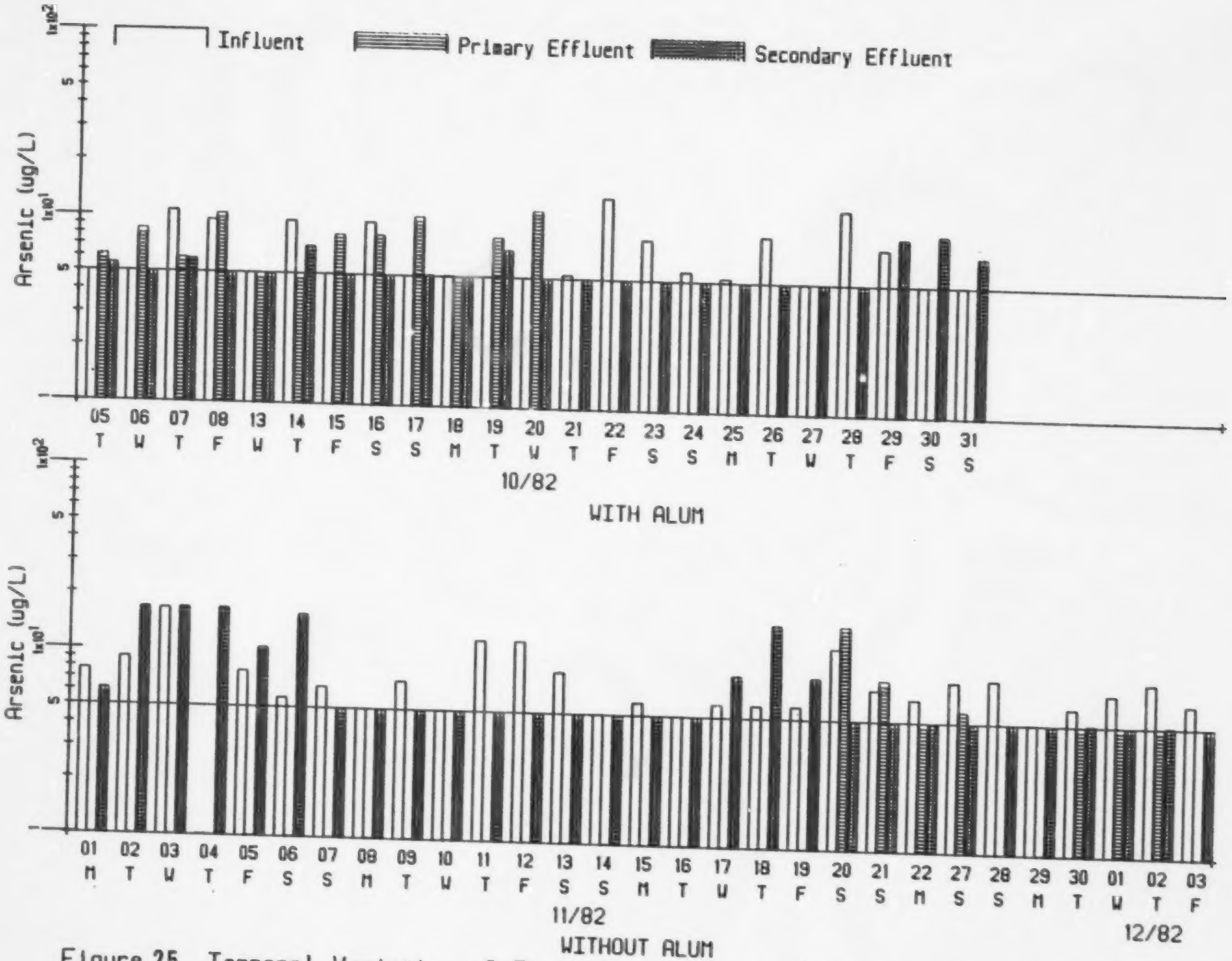
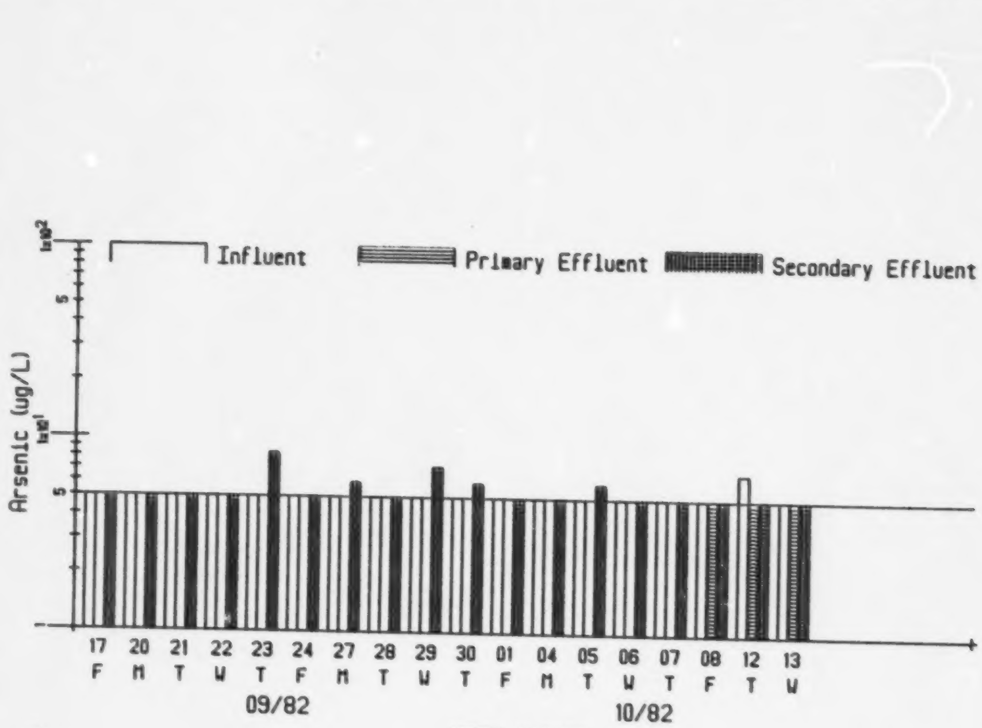
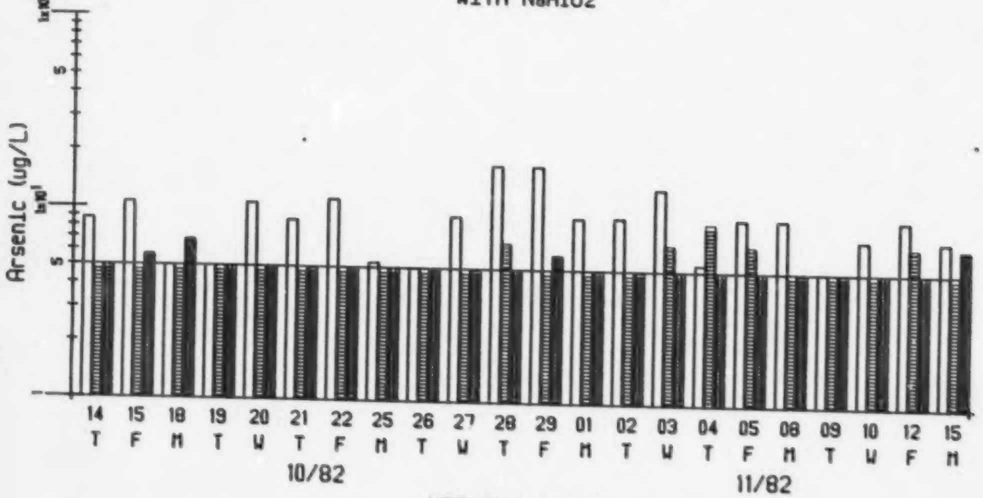


Figure 25 Temporal Variation of Total Arsenic at Fitchburg (MA) POTW

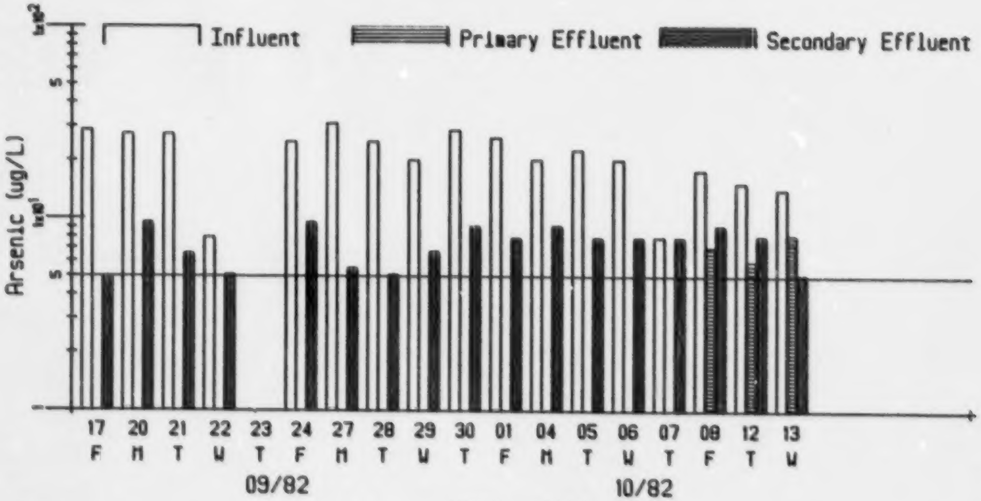


WITH NaAl02

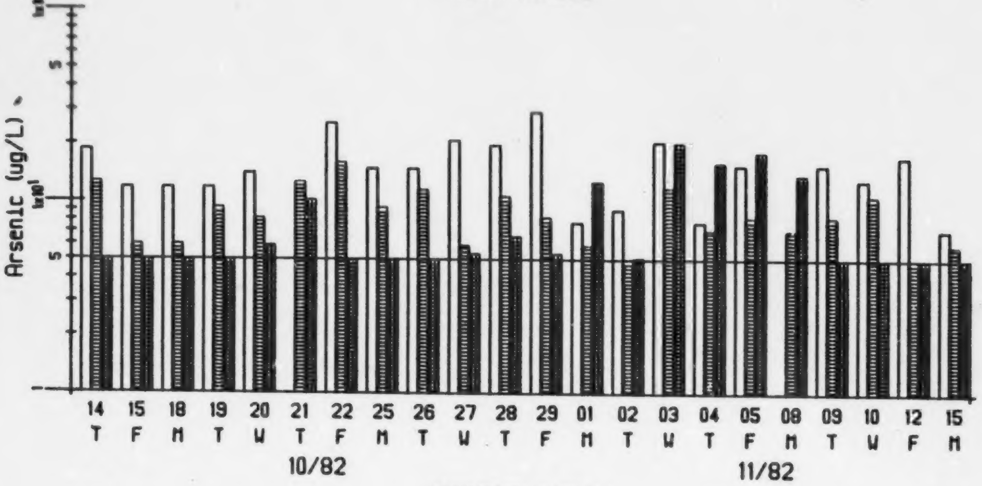


WITHOUT NaAl02

Figure 26 Temporal Variation of Soluble Arsenic at Pittsfield (MA) POTW

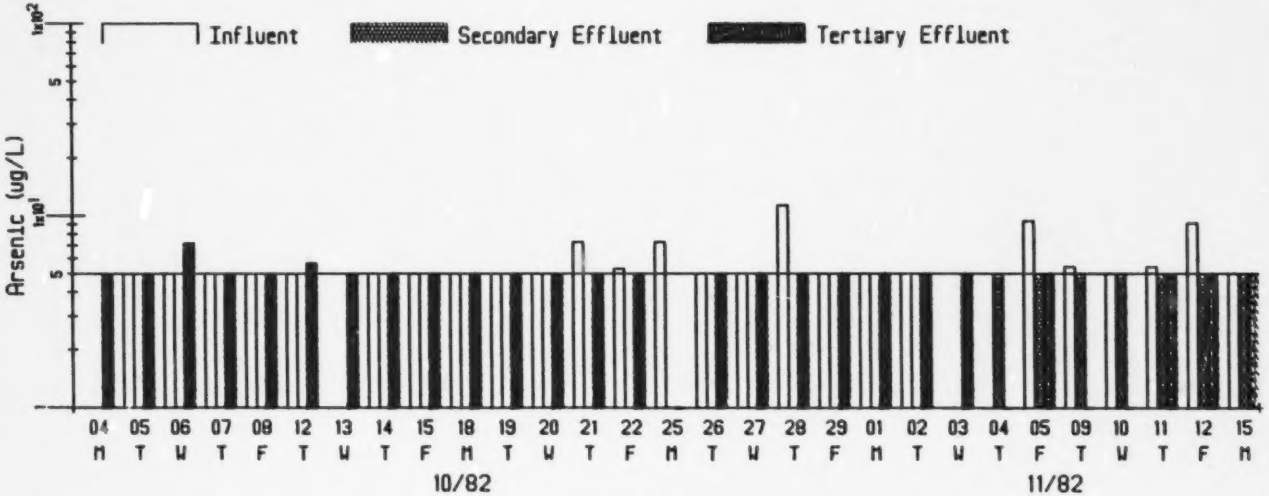


WITH NaAlO2

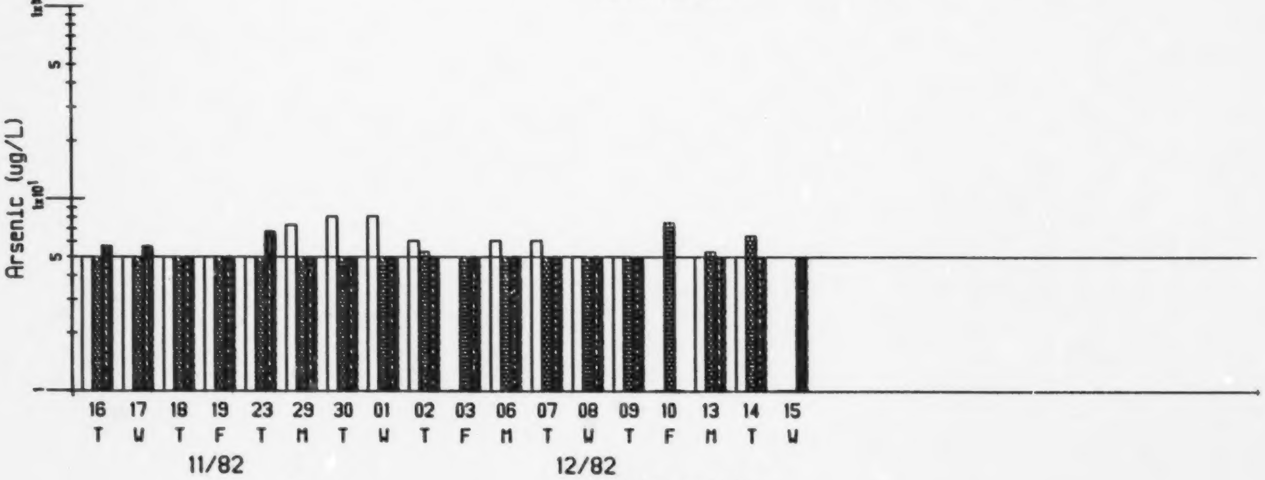


WITHOUT NaAlO2

Figure 27 Temporal Variation of Total Arsenic at Pittsfield (MA) POTW

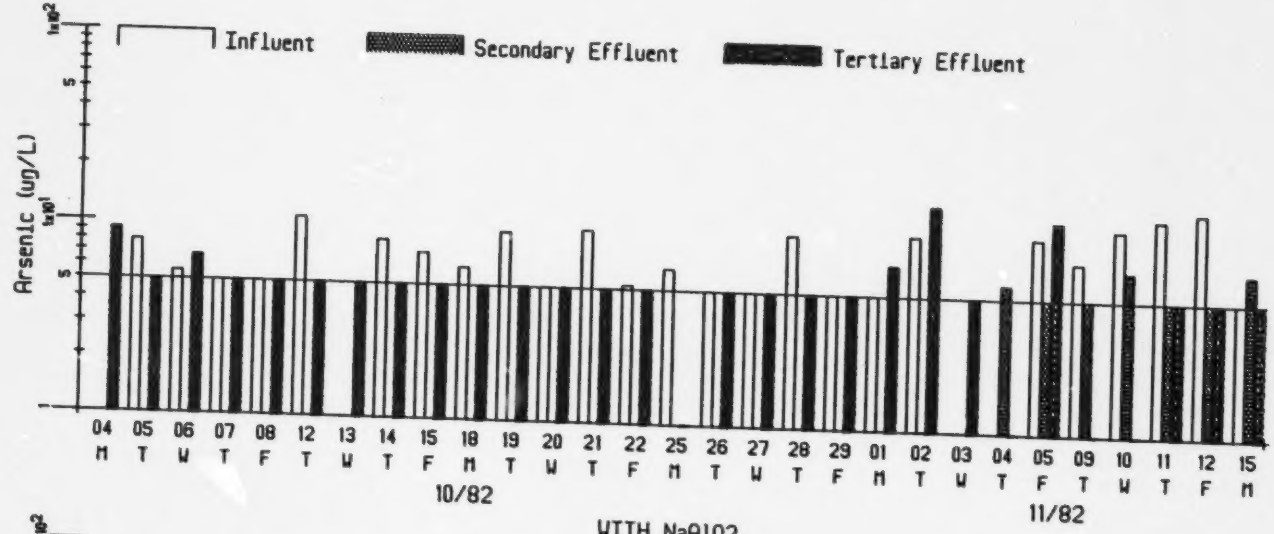


WITH NaAl02

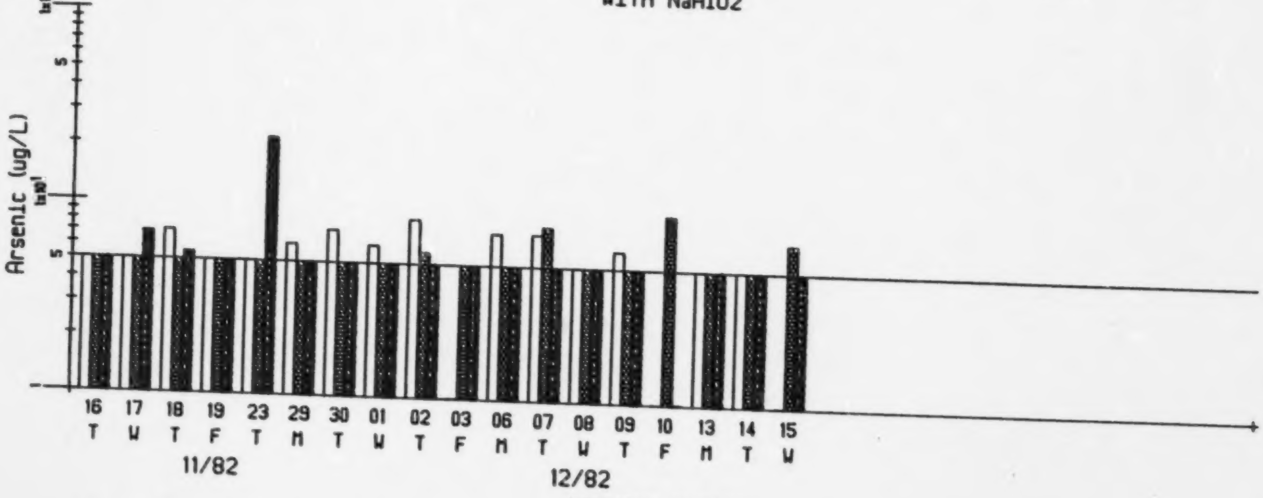


WITHOUT NaAl02

Figure 28 Temporal Variation of Soluble Arsenic at Medfield (MA) POTW



WITH NaAlO2



WITHOUT NaAlO2

Figure 29 Temporal Variation of Total Arsenic at Medfield (MA) POTW

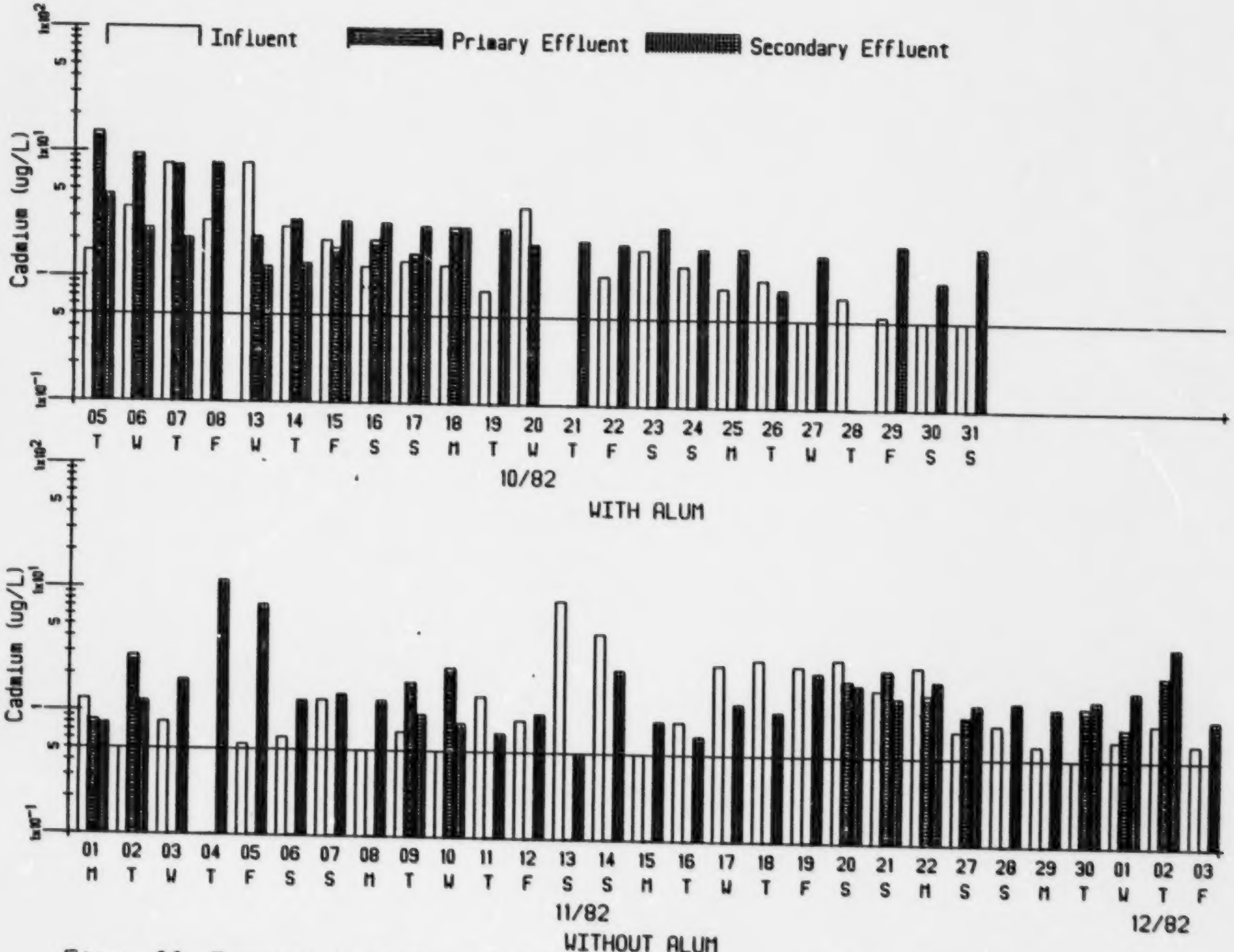


Figure 30 Temporal Variation of Soluble Cadmium at Fitchburg (MA) POTW

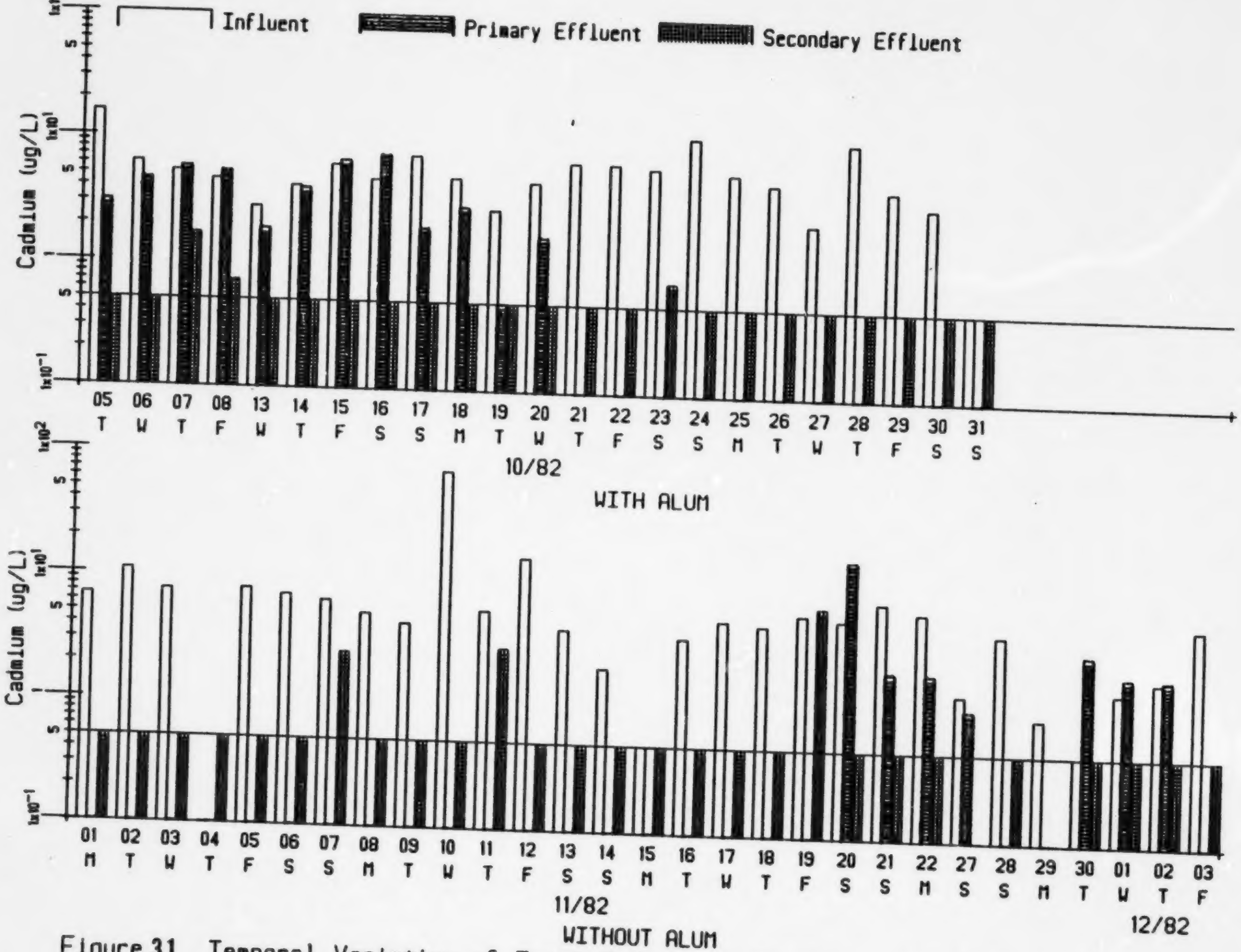


Figure 31 Temporal Variation of Total Cadmium at Fitchburg (MA) POTW

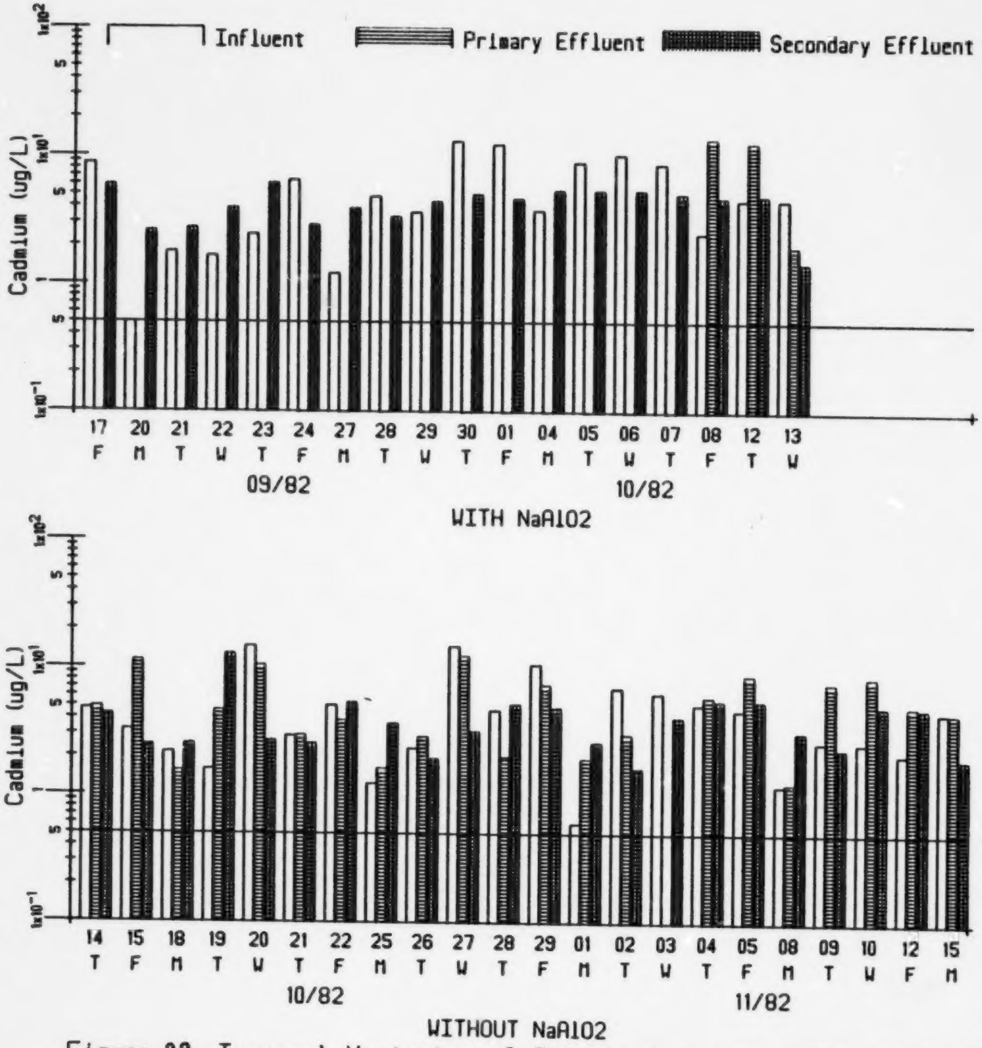
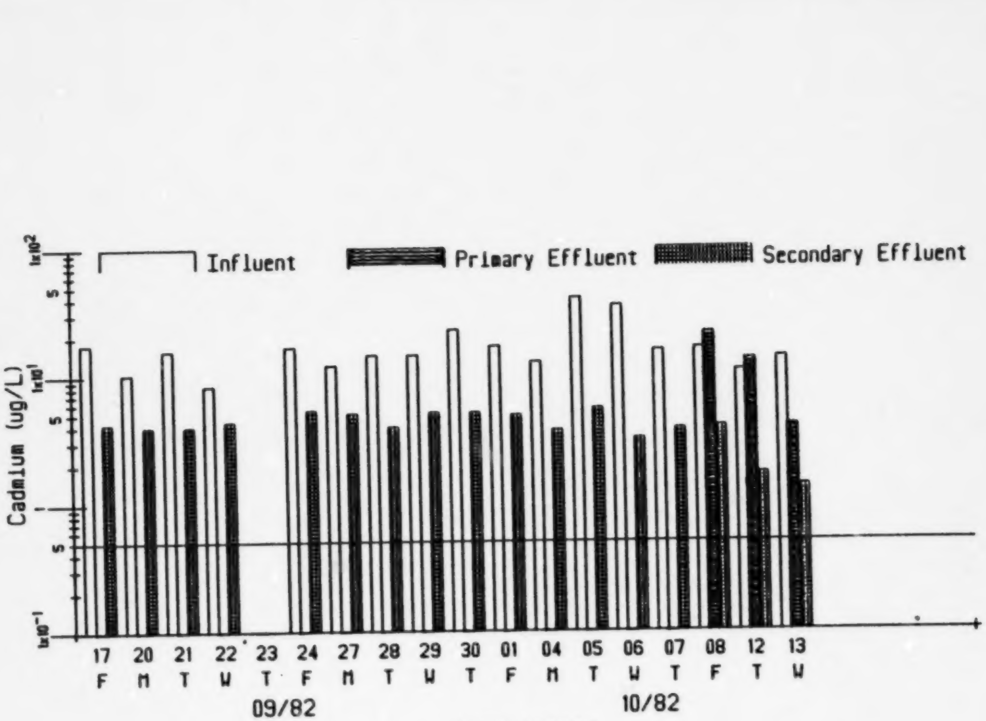
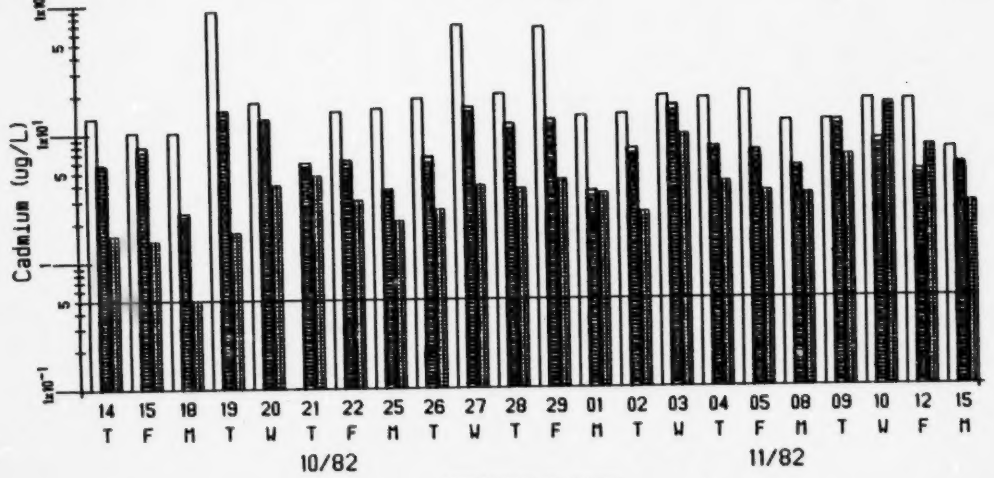


Figure 32 Temporal Variation of Soluble Cadmium at Pittsfield (MA) POTW



WITH NaA102



WITHOUT NaA102

Figure 33 Temporal Variation of Total Cadmium at Pittsfield (MA) POTW

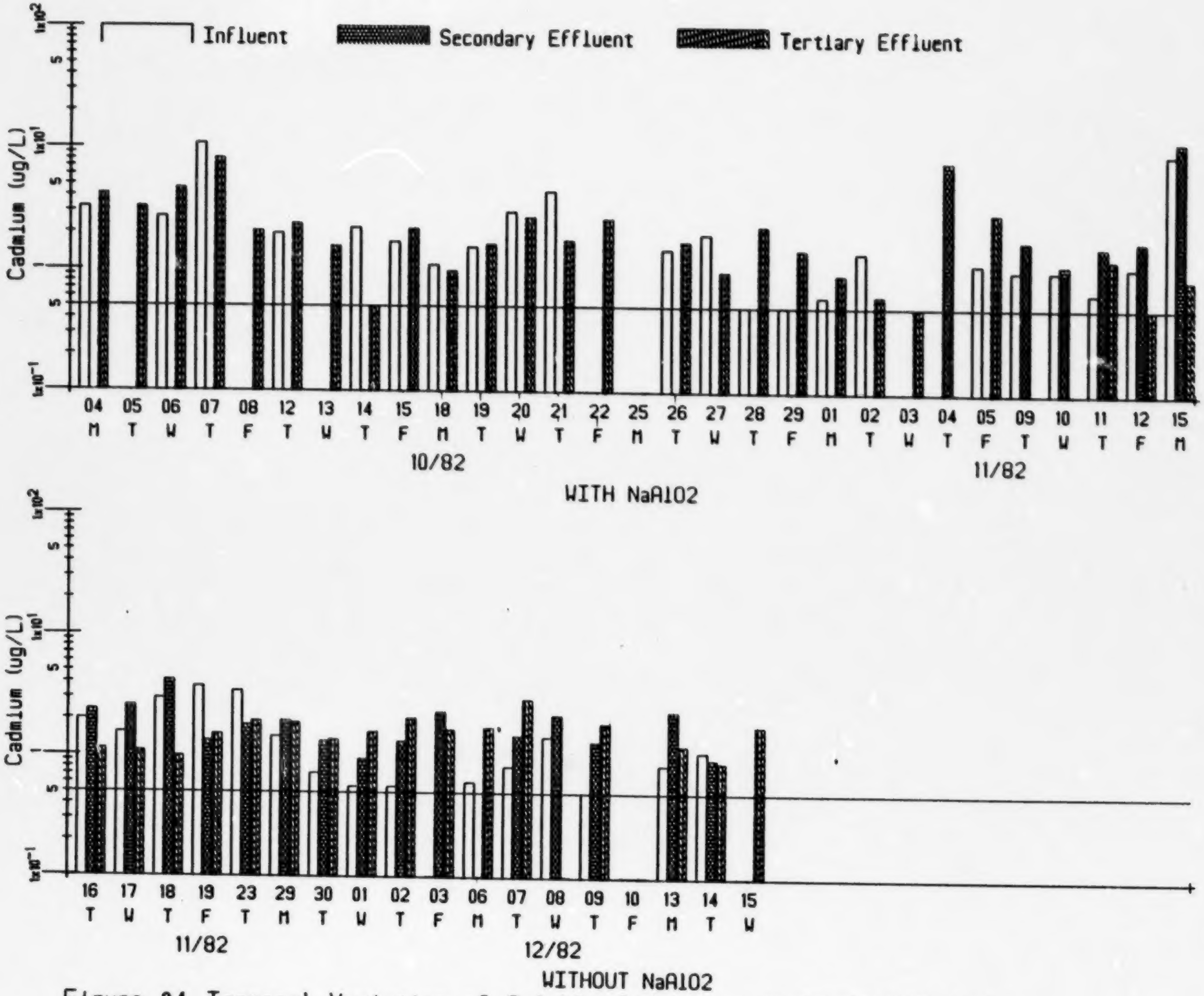


Figure 34 Temporal Variation of Soluble Cadmium at Medfield (MA) POTW

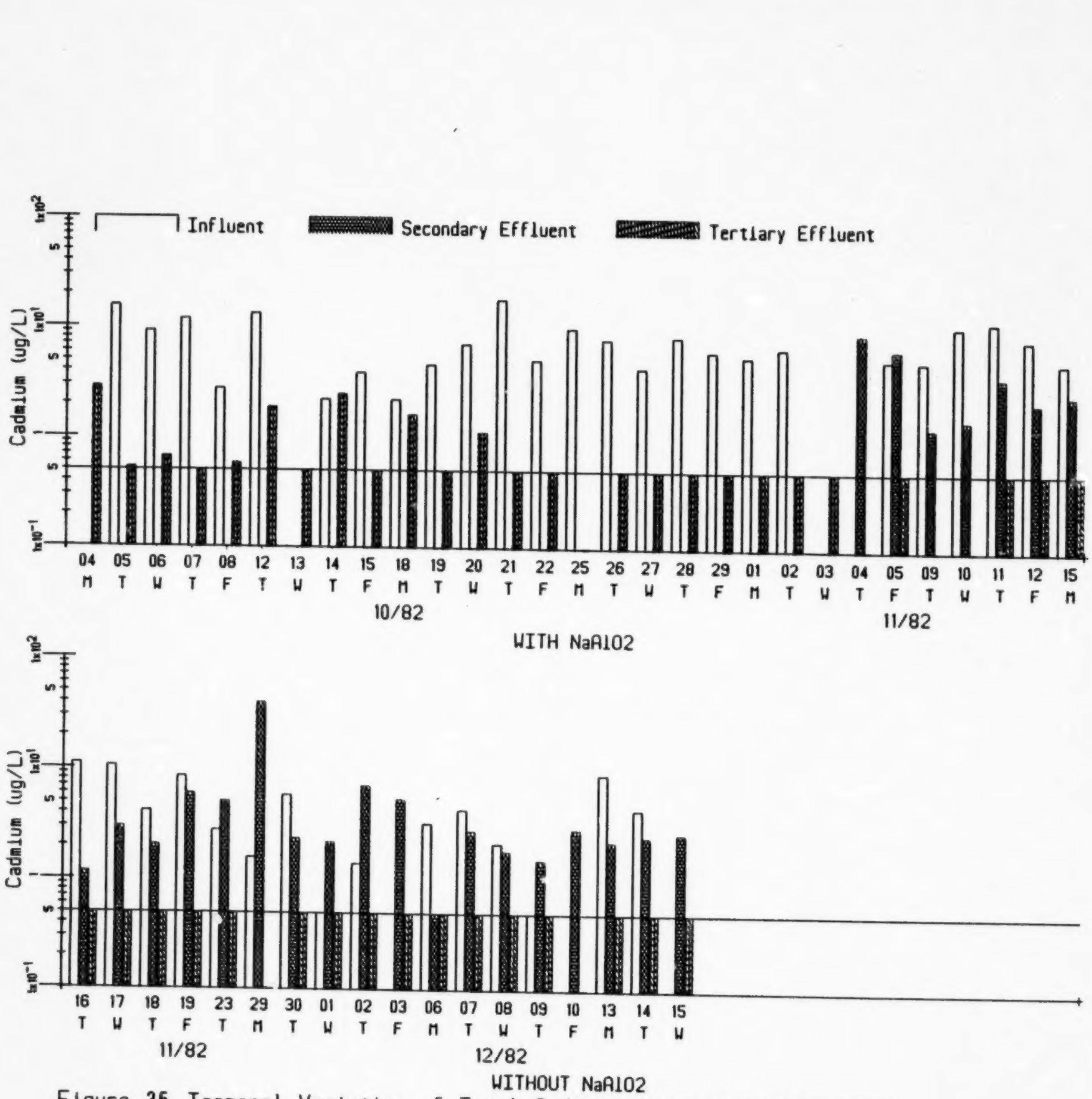


Figure 35 Temporal Variation of Total Cadmium at Medfield (MA) POTW

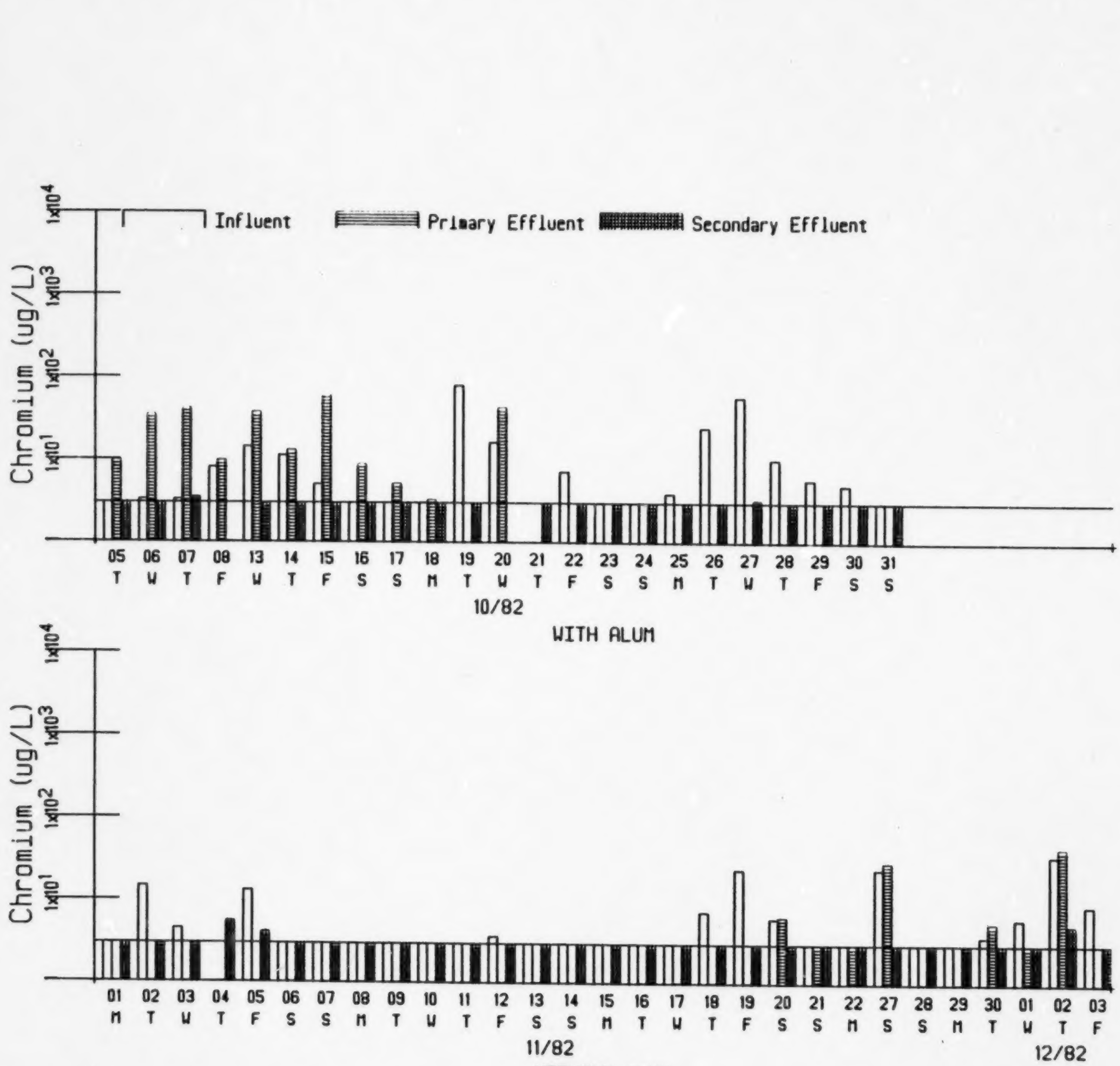


Figure 36 Temporal Variation of Soluble Chromium at Fitchburg (MA) POTW

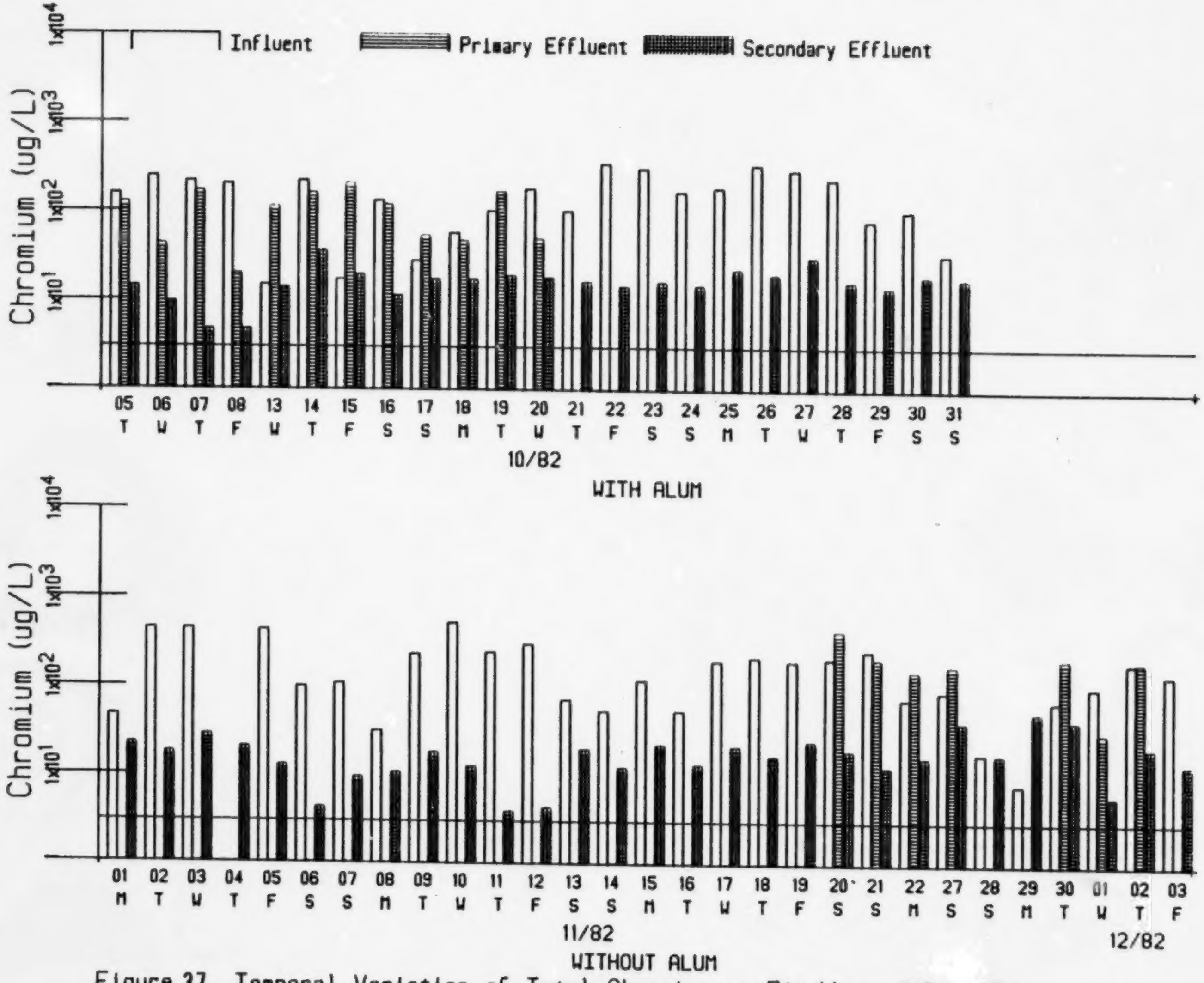


Figure 37 Temporal Variation of Total Chromium at Fitchburg (MA) POTW

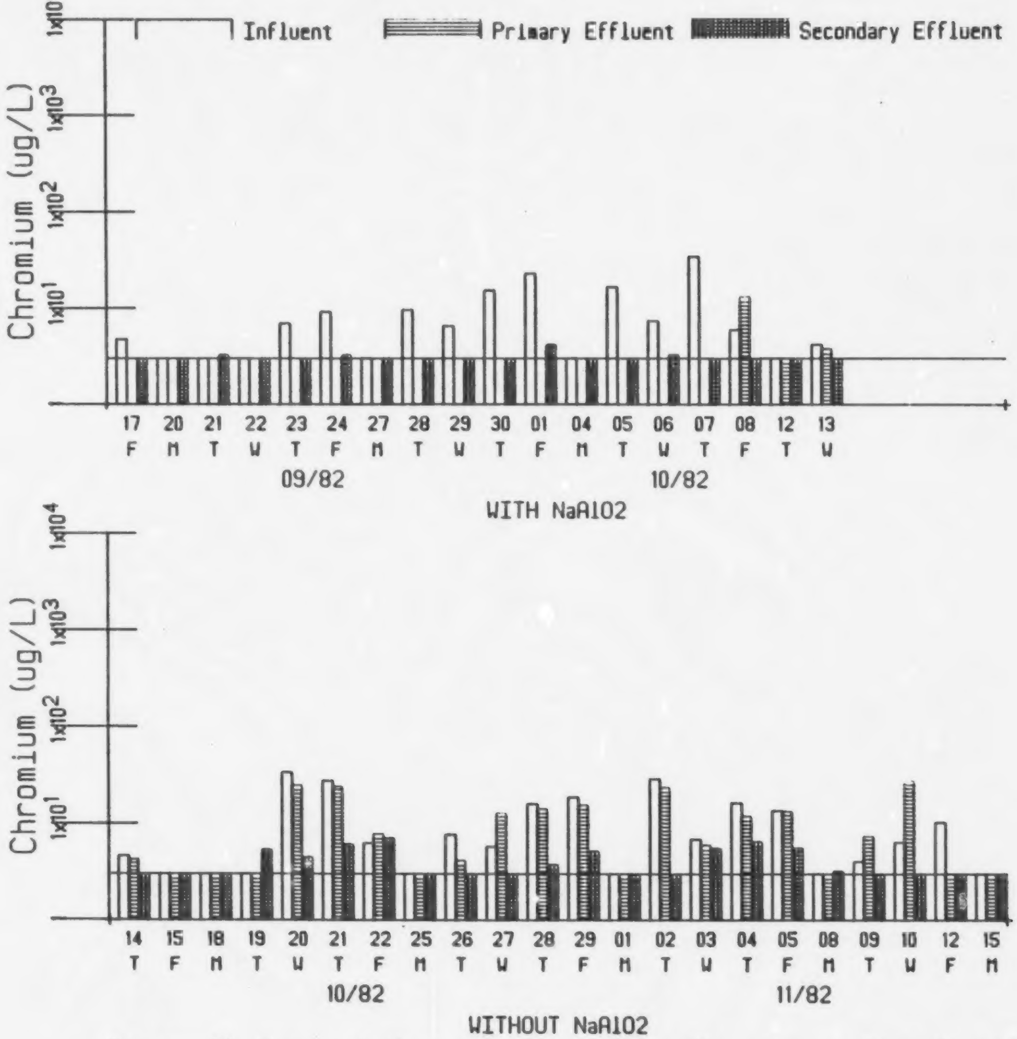


Figure 38 Temporal Variation of Soluble Chromium at Pittsfield (MA) POTW

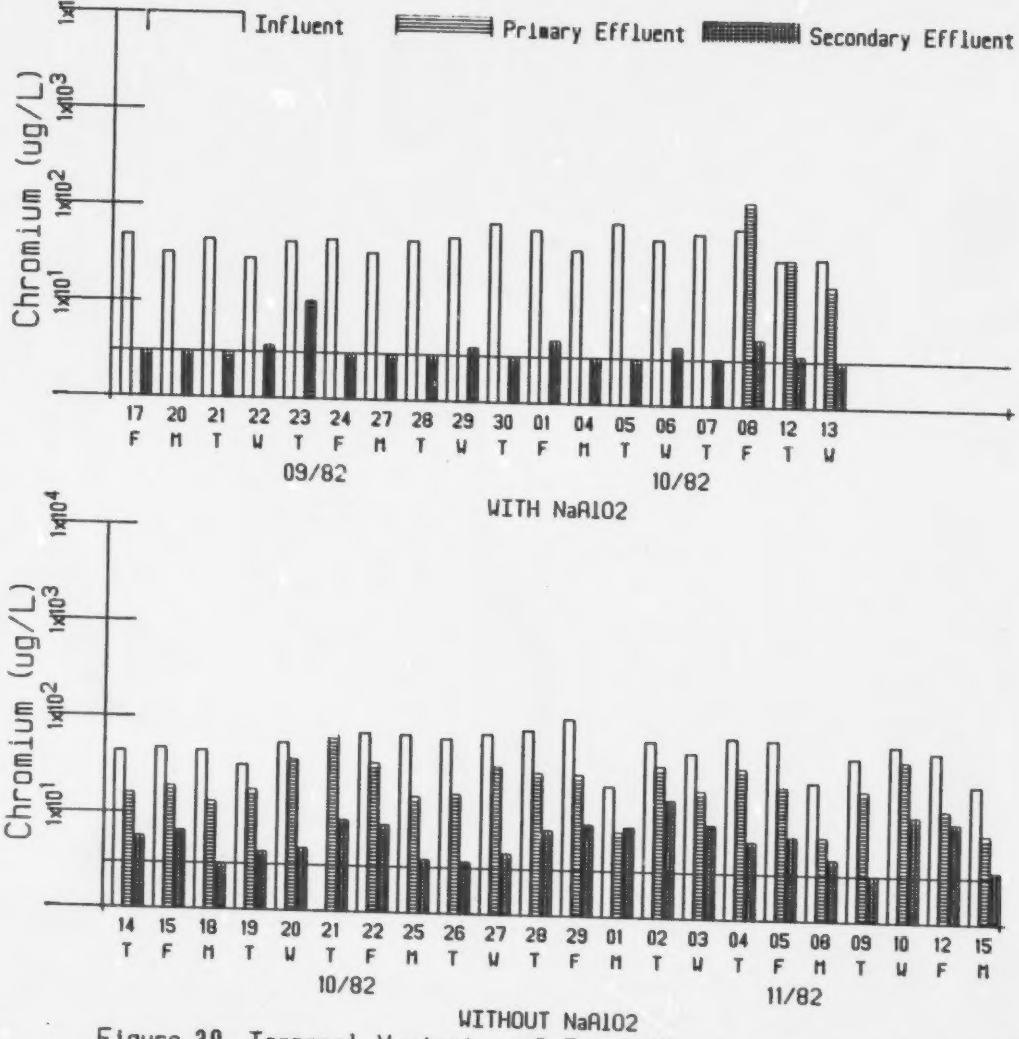


Figure 39 Temporal Variation of Total Chromium at Pittsfield (MA) POTW

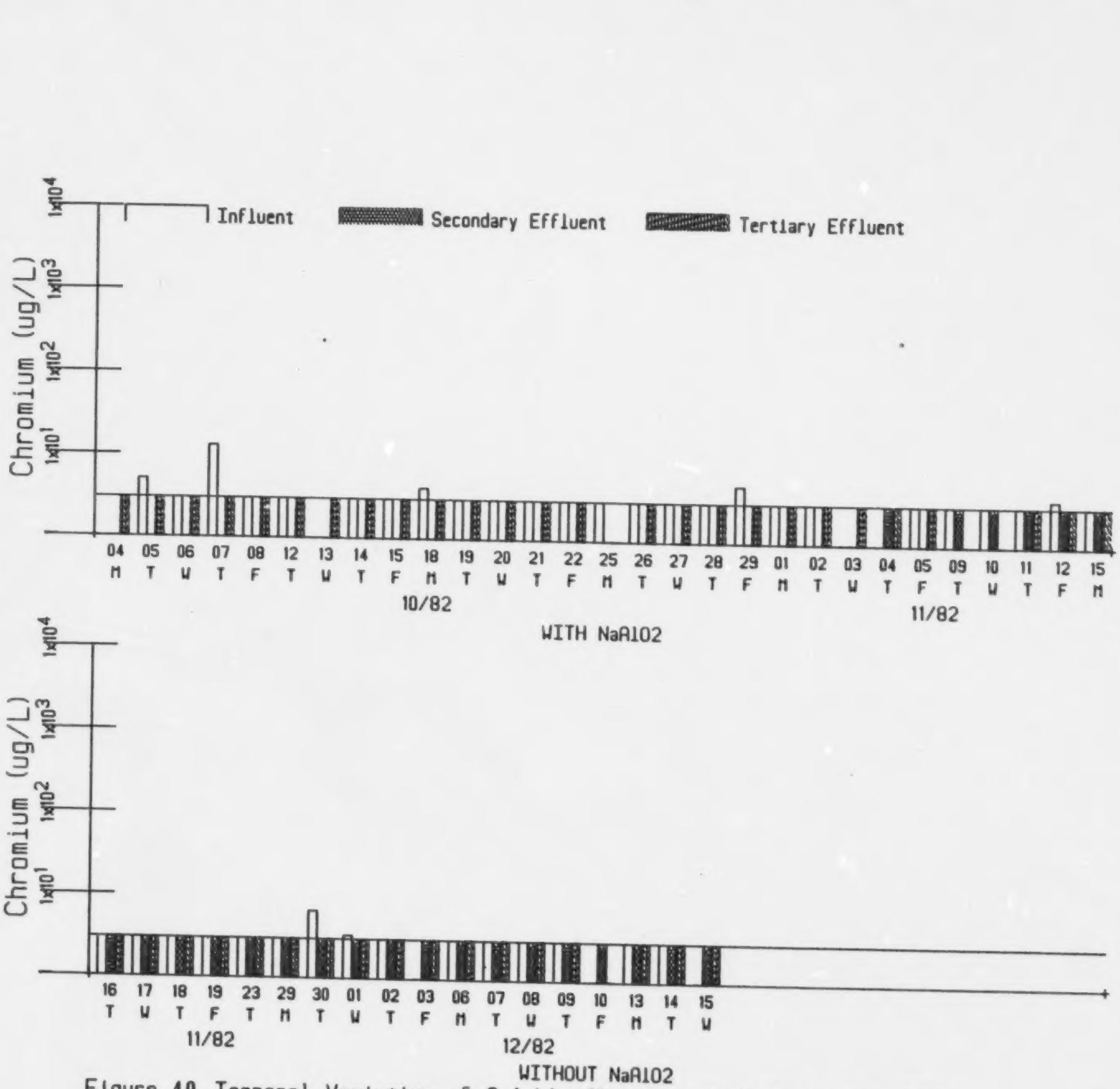
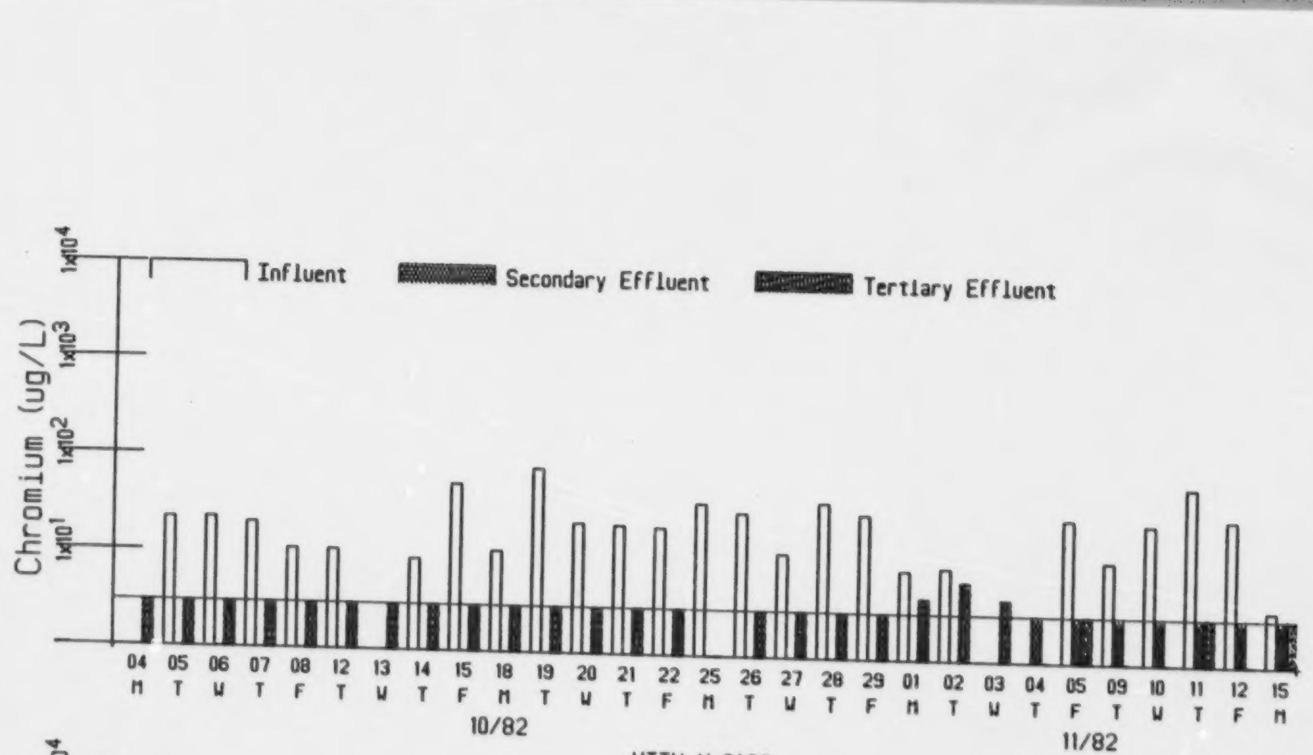
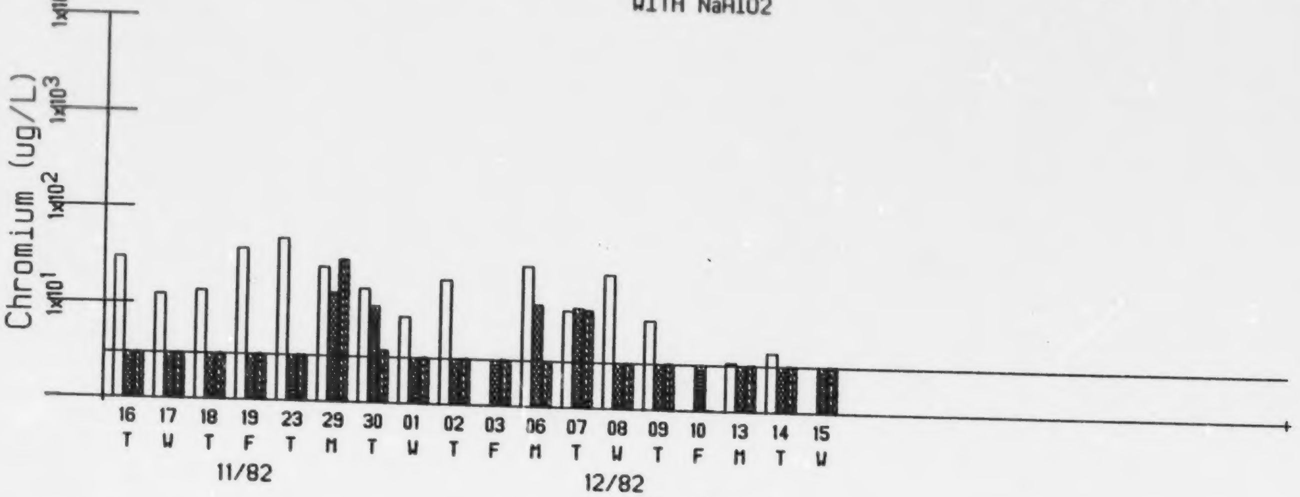


Figure 40 Temporal Variation of Soluble Chromium at Medfield (MA) POTW

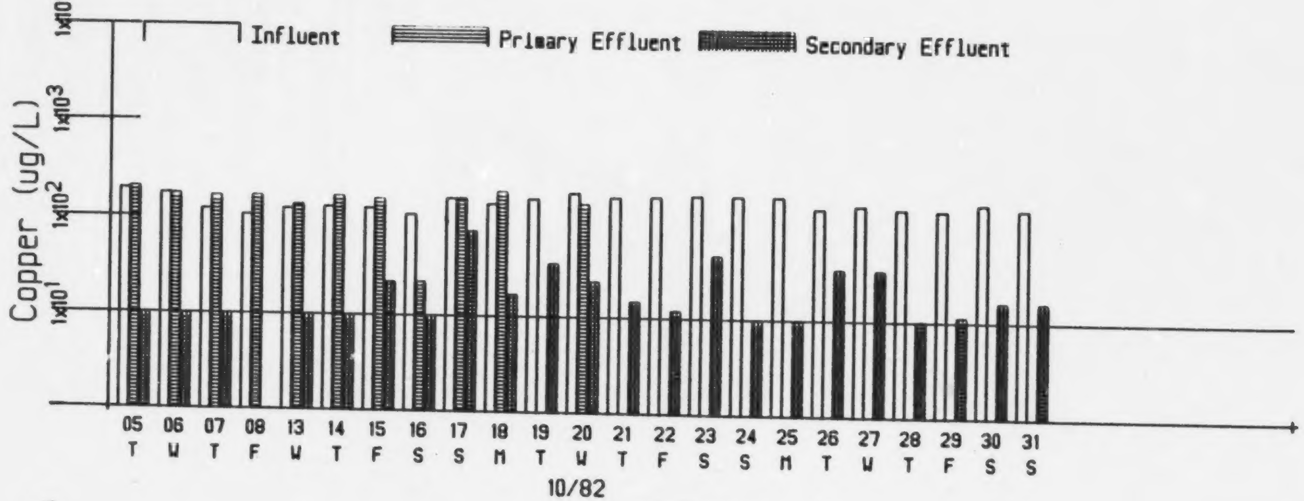


WITH NaA102

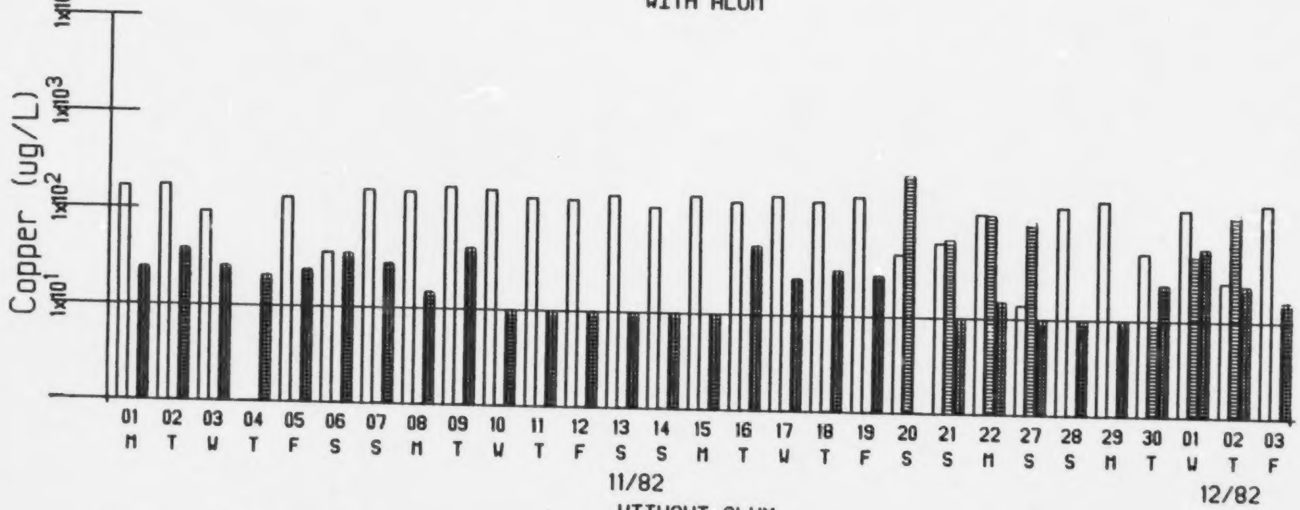


WITHOUT NaA102

Figure 41 Temporal Variation of Total Chromium at Medfield (MA) POTW



WITH ALUM



WITHOUT ALUM

Figure 42 Temporal Variation of Soluble Copper at Fitchburg (MA) POTW

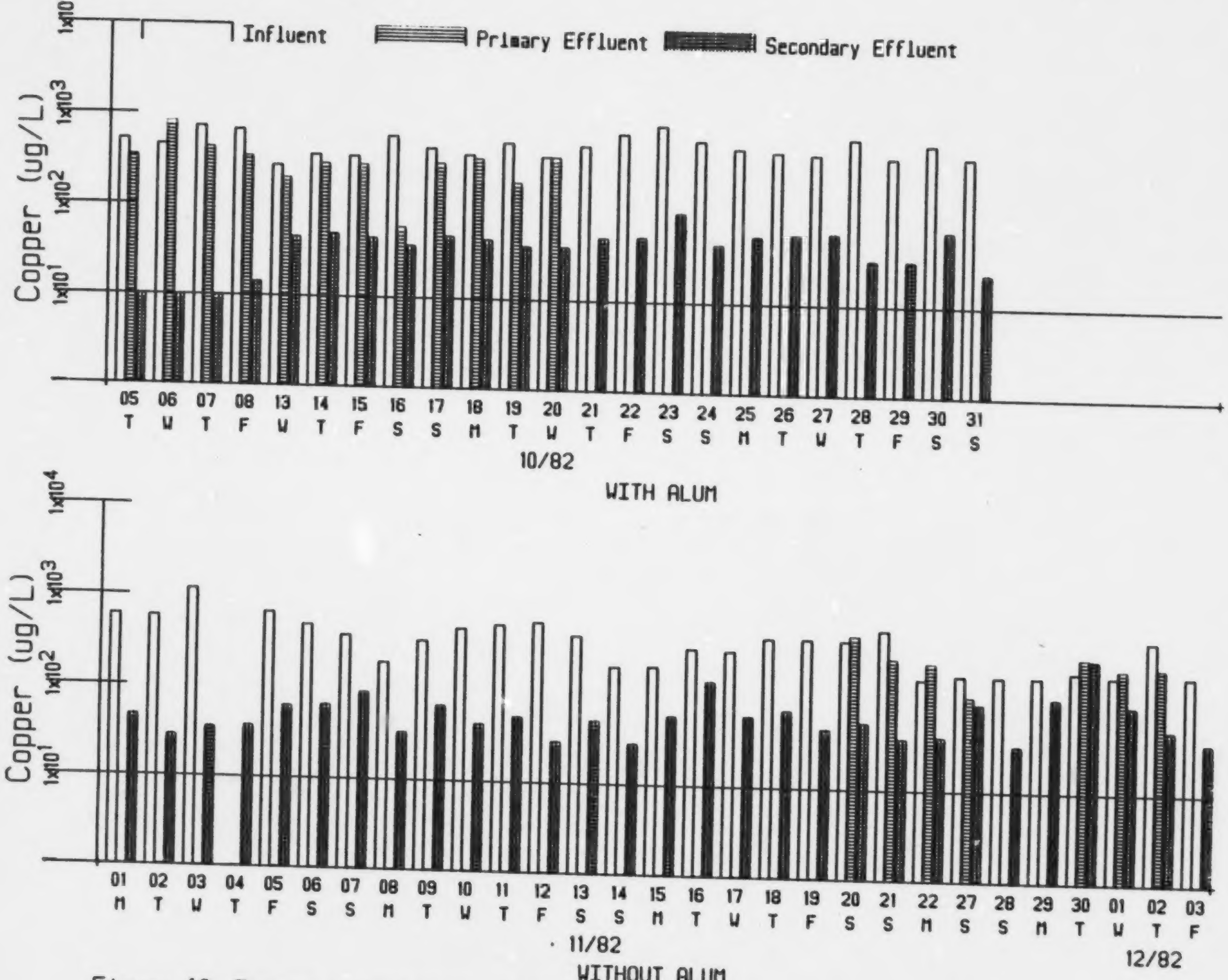
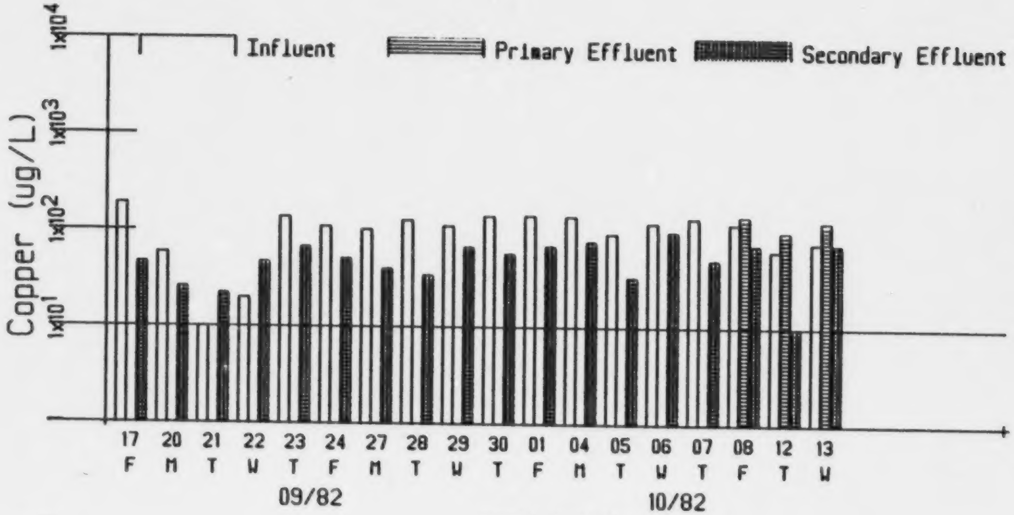
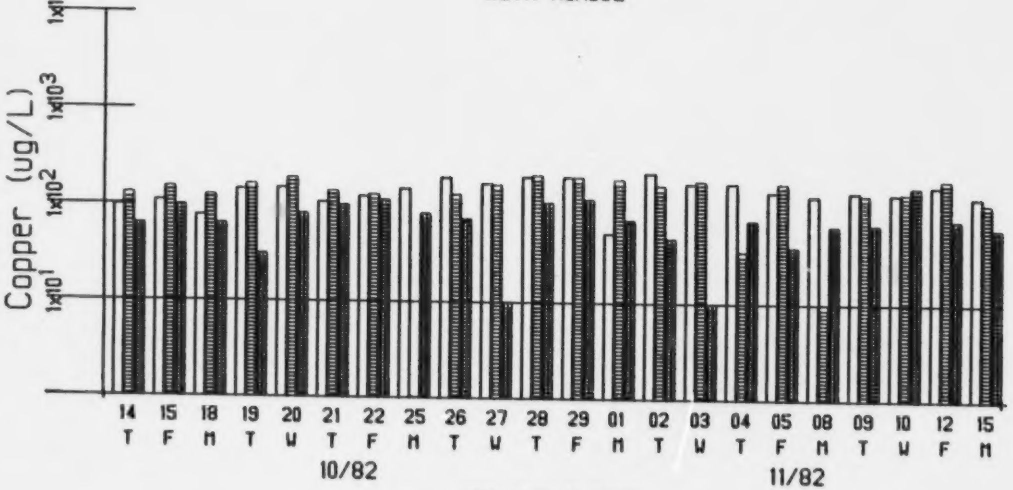


Figure 43 Temporal Variation of Total Copper at Fitchburg (MA) POTW

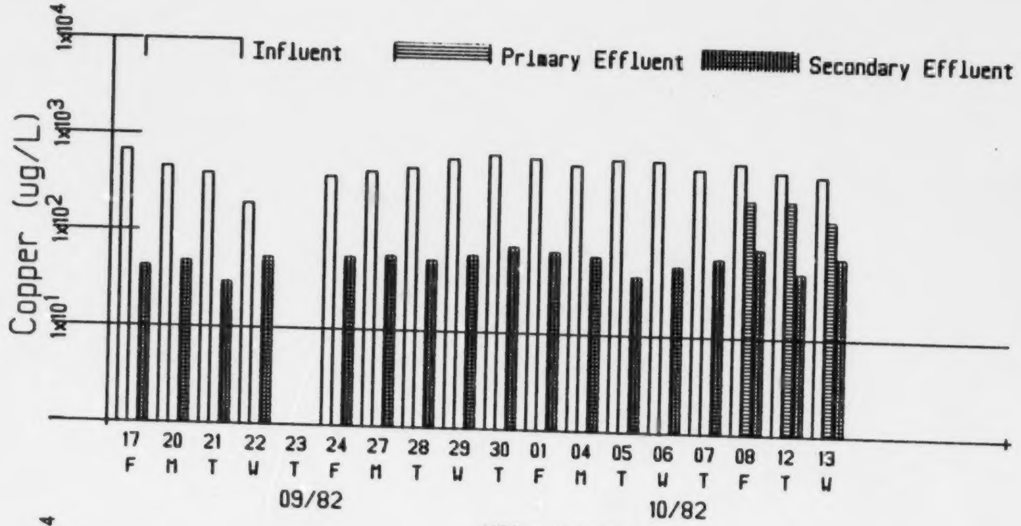


WITH NaAl02

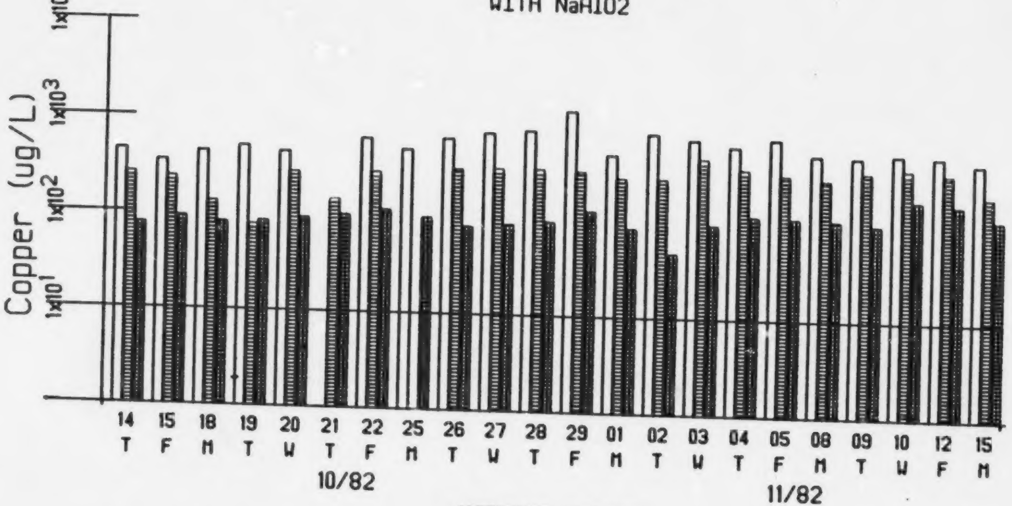


WITHOUT NaAl02

Figure 44 Temporal Variation of Soluble Copper at Pittsfield (MA) POTW

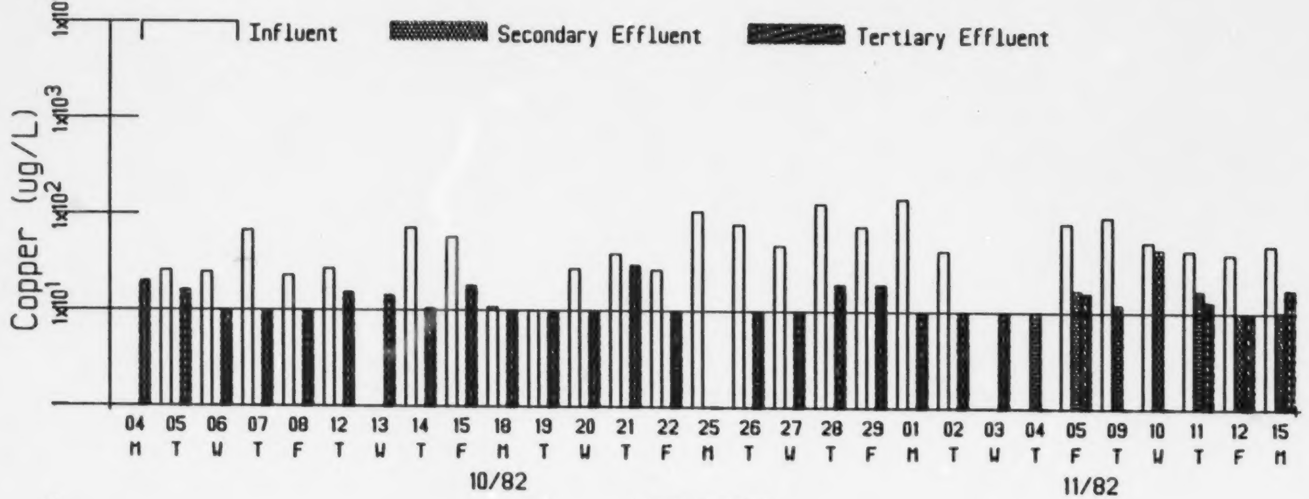


WITH NaA102

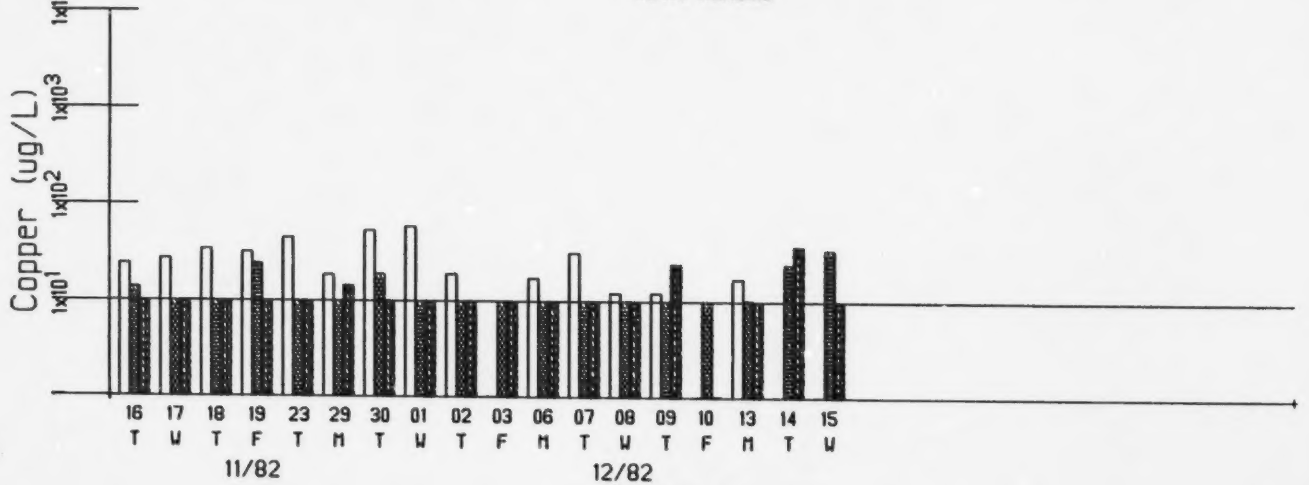


WITHOUT NaA102

Figure 45 Temporal Variation of Total Copper at Pittsfield (MA) POTW



WITH NaAl02



WITHOUT NaAl02

Figure 46 Temporal Variation of Soluble Copper at Medfield (MA) POTW

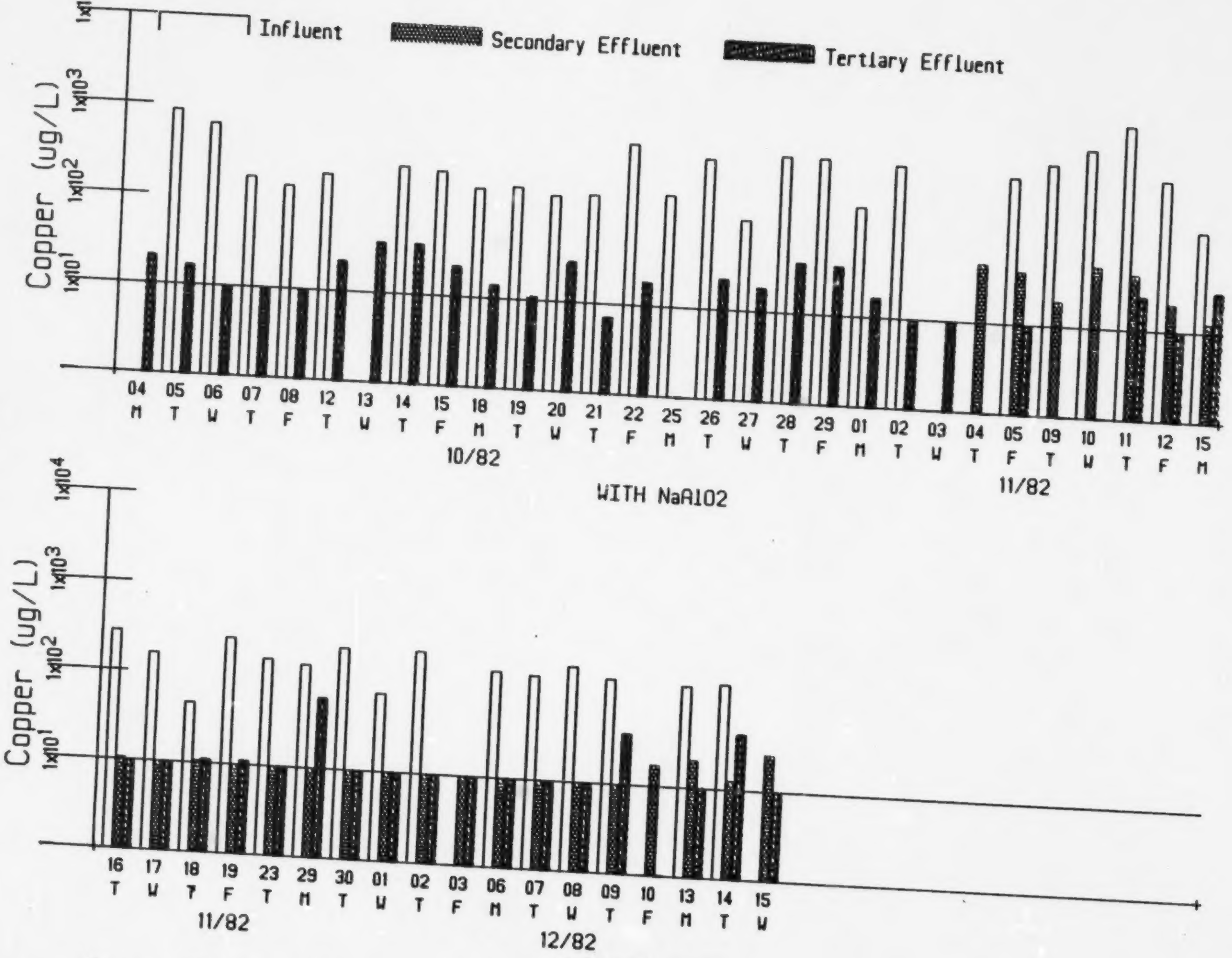


Figure 47 Temporal Variation of Total Copper at Medfield (MA) POTW

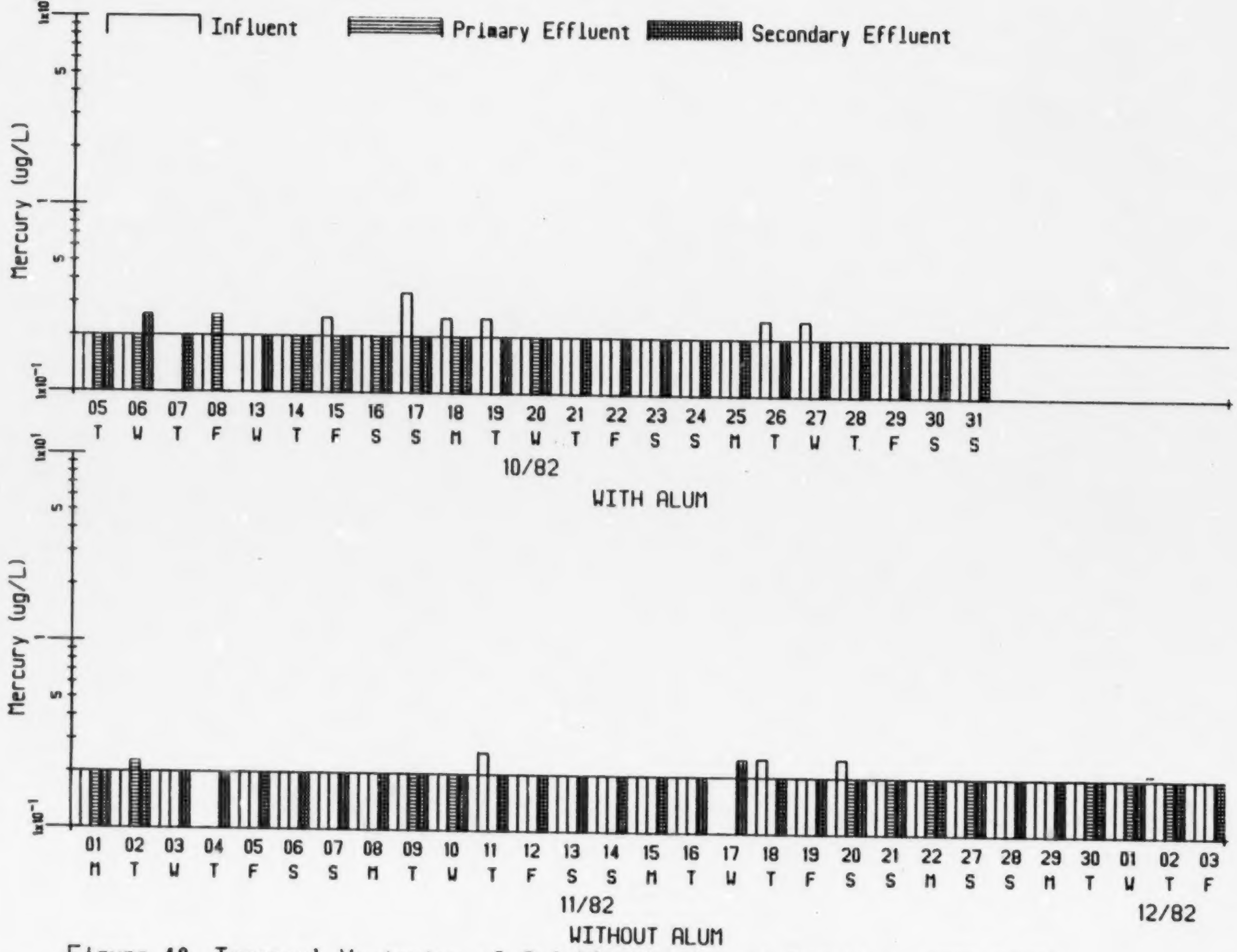


Figure **48** Temporal Variation of Soluble Mercury at Fitchburg (MA) POTW

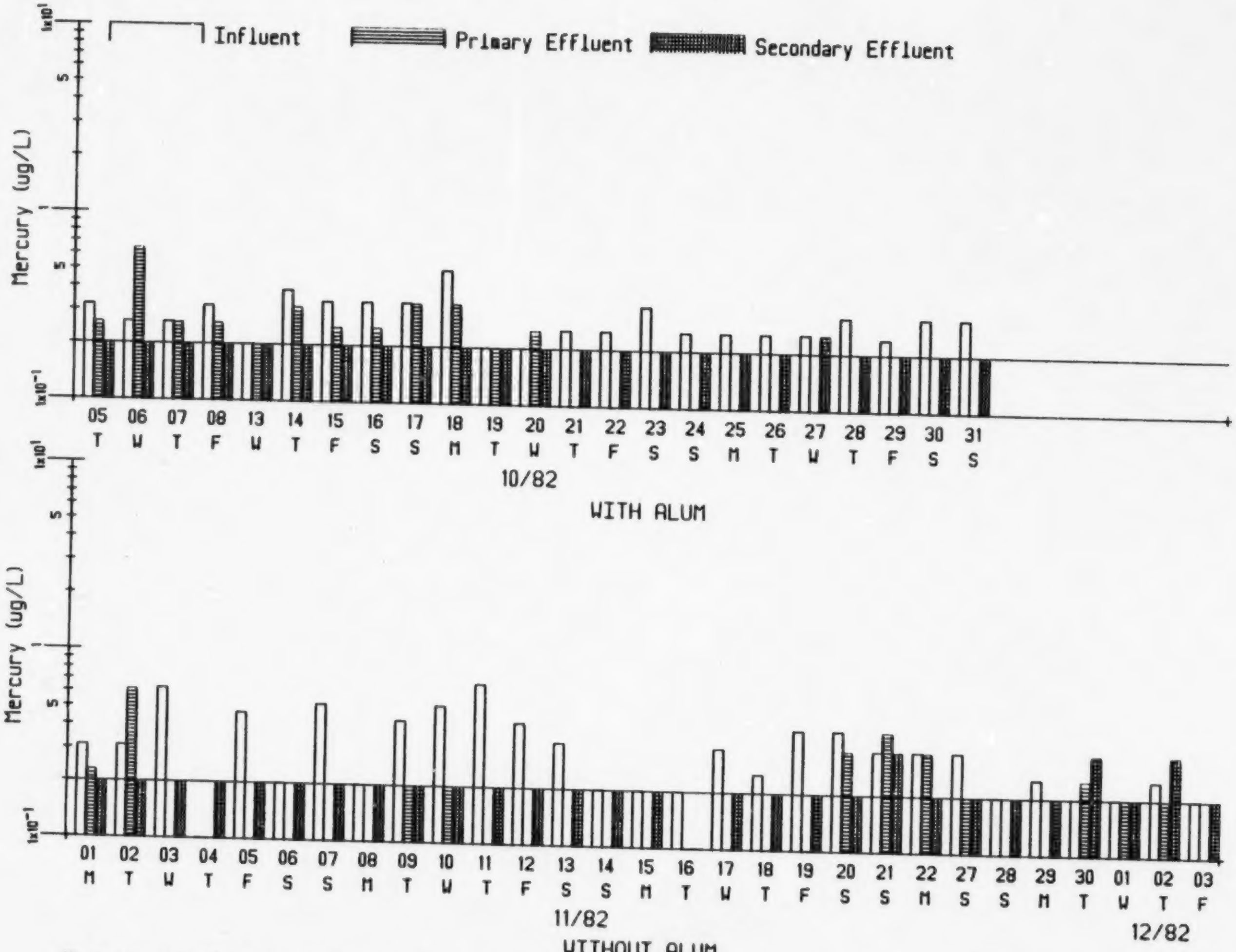


Figure 49 Temporal Variation of Total Mercury at Fitchburg (MA) POTW

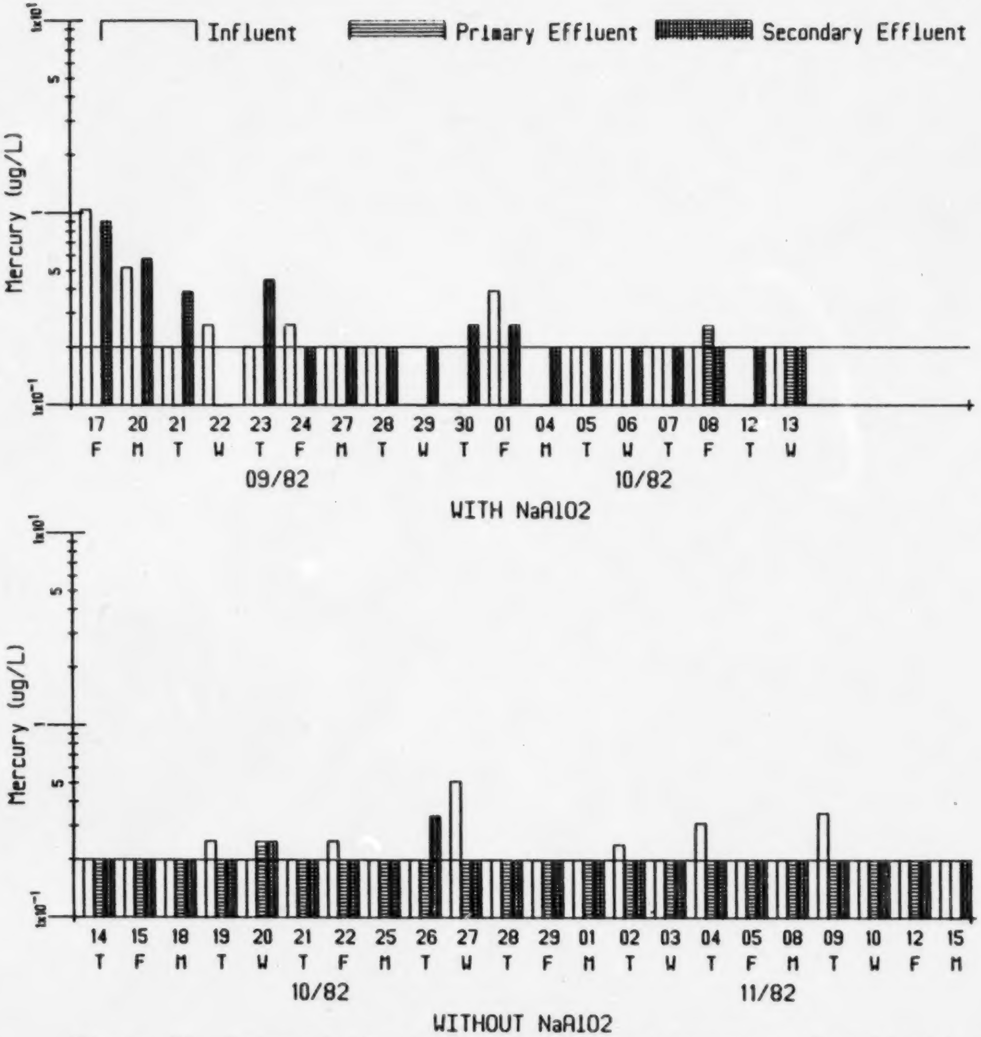
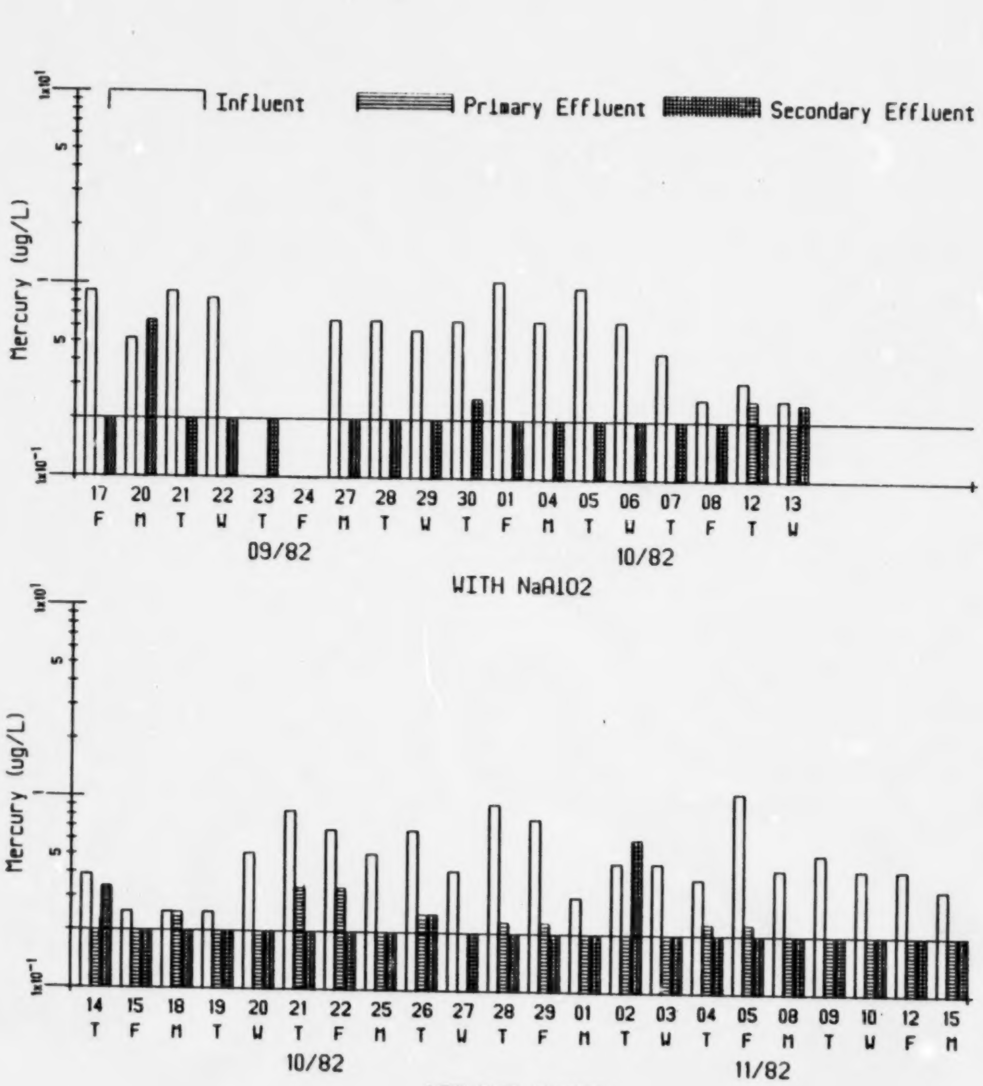


Figure 50 Temporal Variation of Soluble Mercury at Pittsfield (MA) POTW



WITH NaAlO2

WITHOUT NaAlO2

Figure **51** Temporal Variation of Total Mercury at Pittsfield (MA) POTW

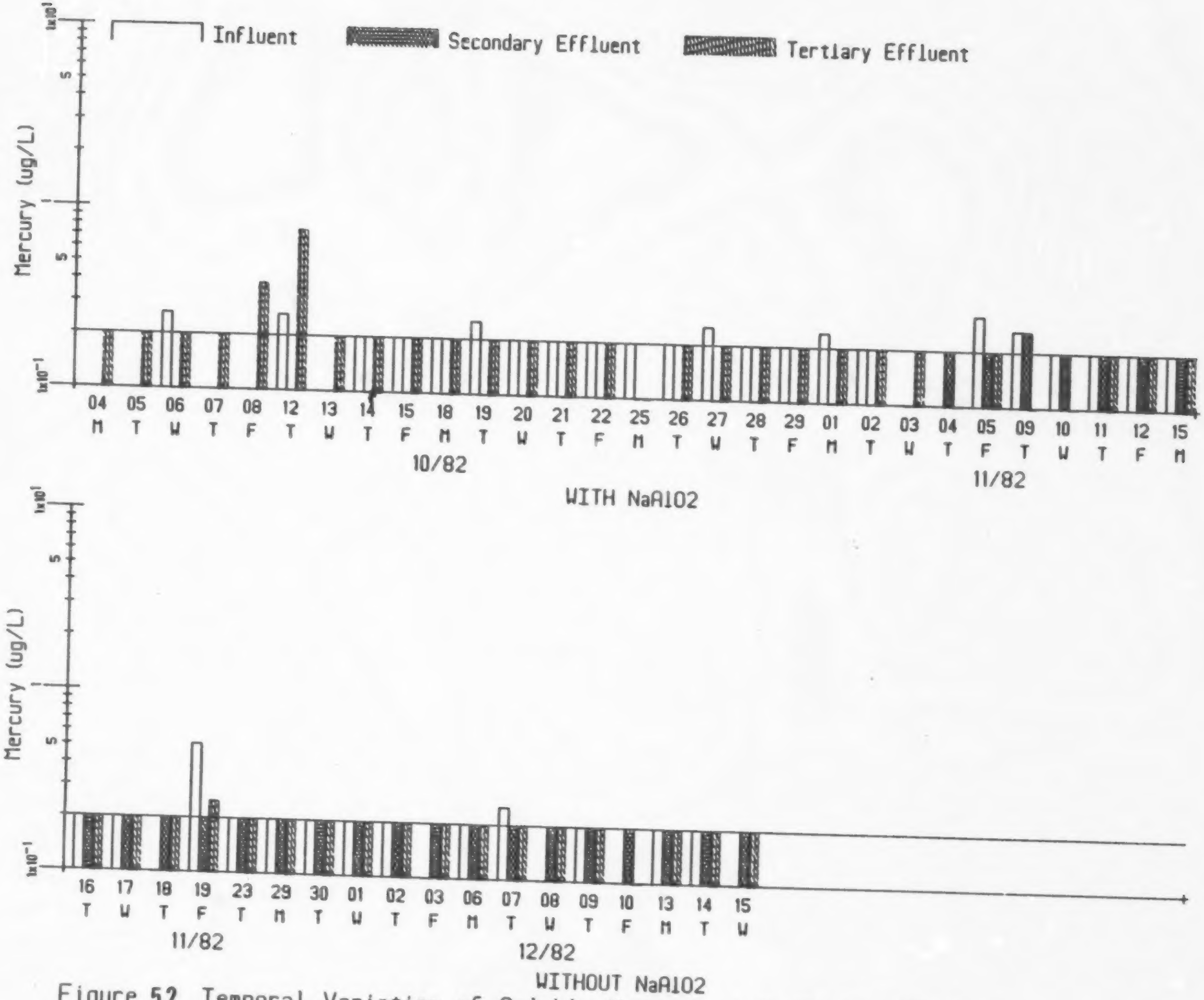
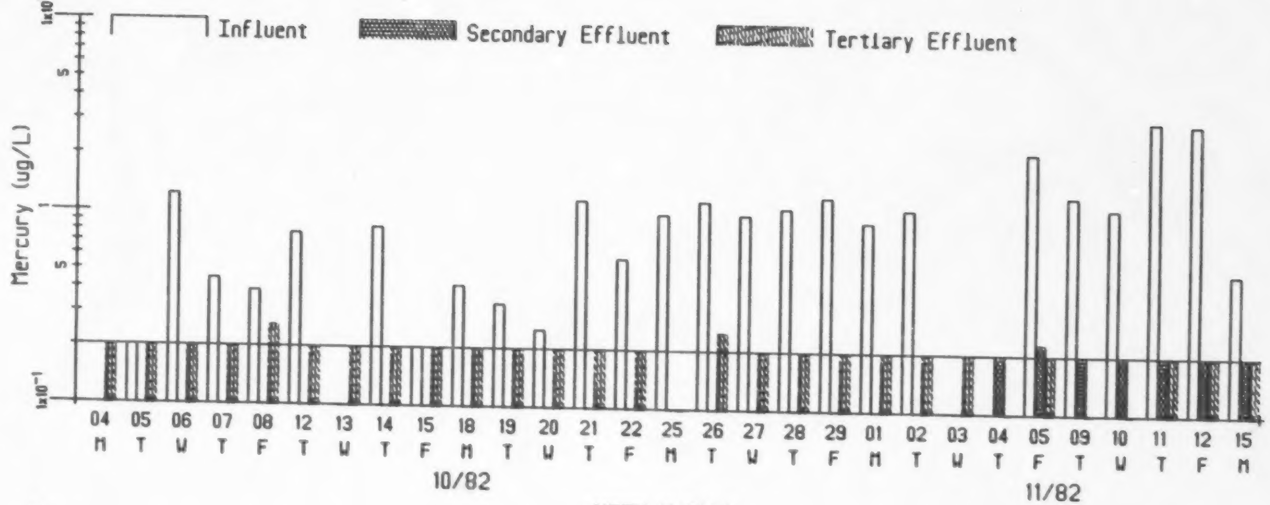
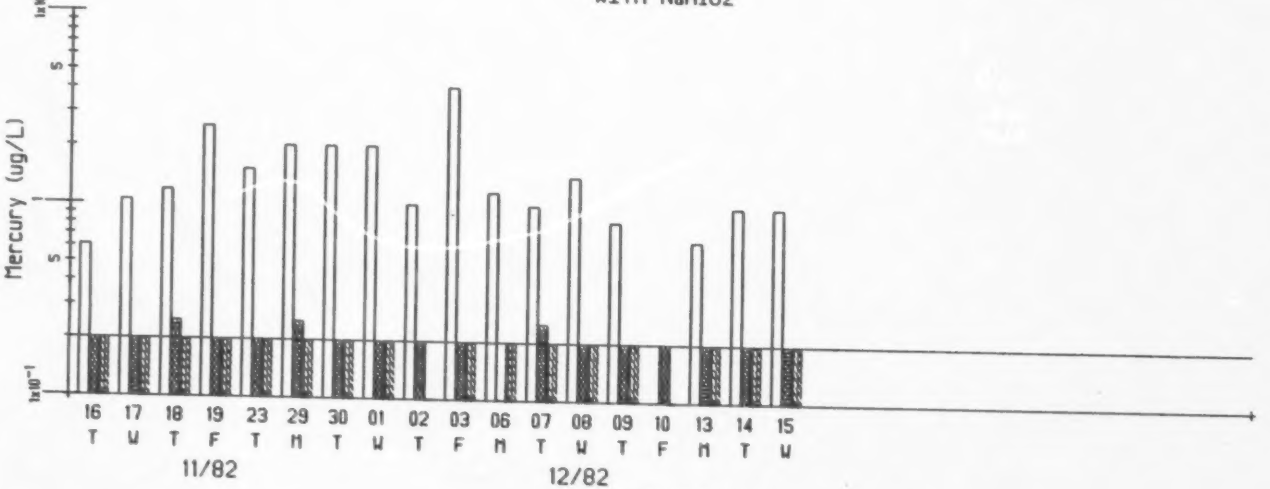


Figure **52** Temporal Variation of Soluble Mercury at Medfield (MA) POTW

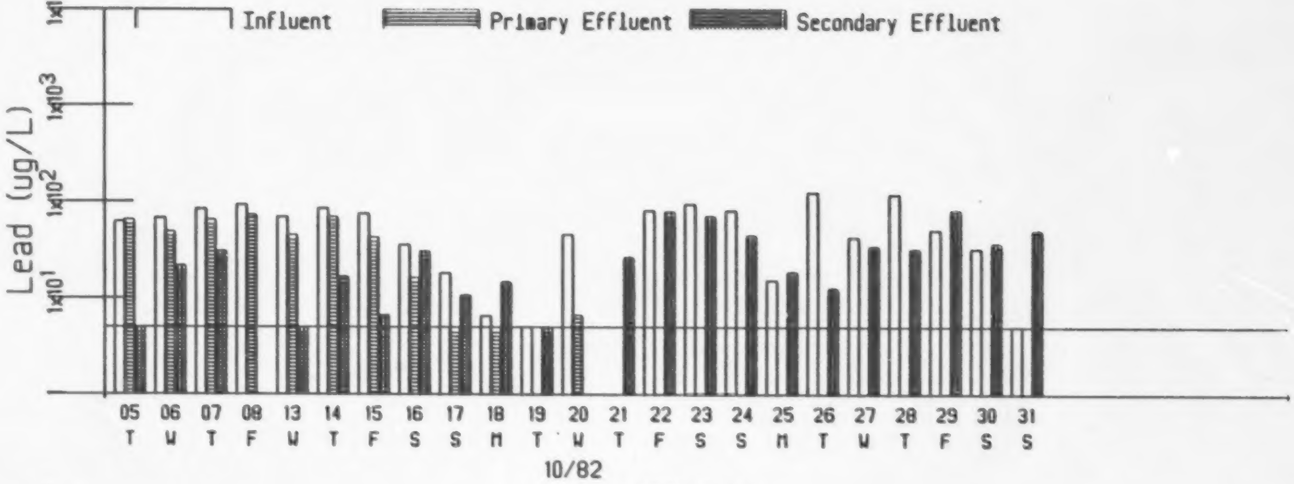


WITH NaA102

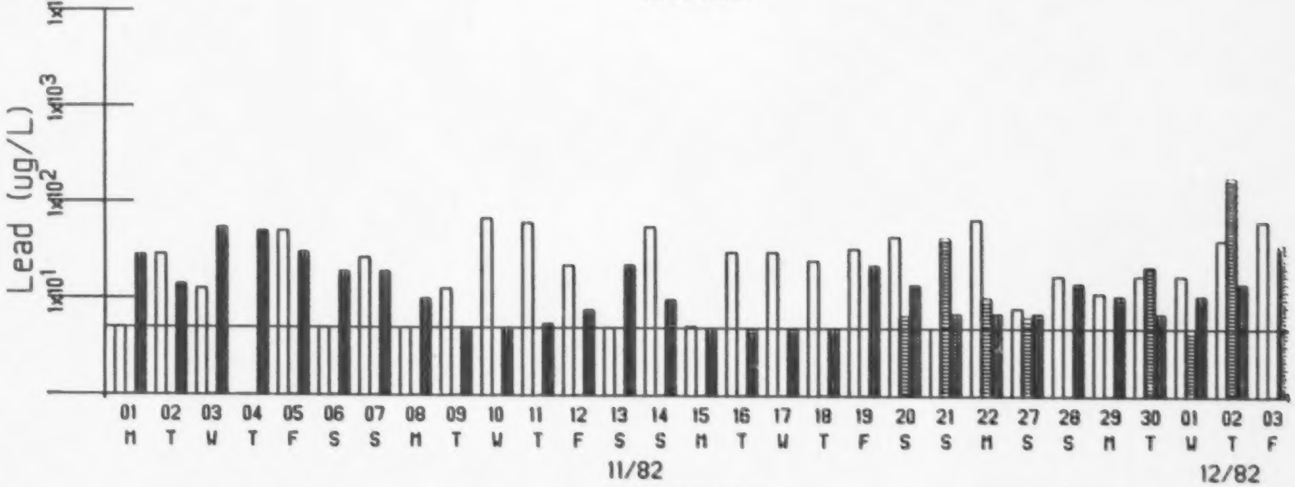


WITHOUT NaA102

Figure 53 Temporal Variation of Total Mercury at Medfield (MA) POTW



WITH ALUM



WITHOUT ALUM

Figure 54 Temporal Variation of Soluble Lead at Fitchburg (MA) POTW

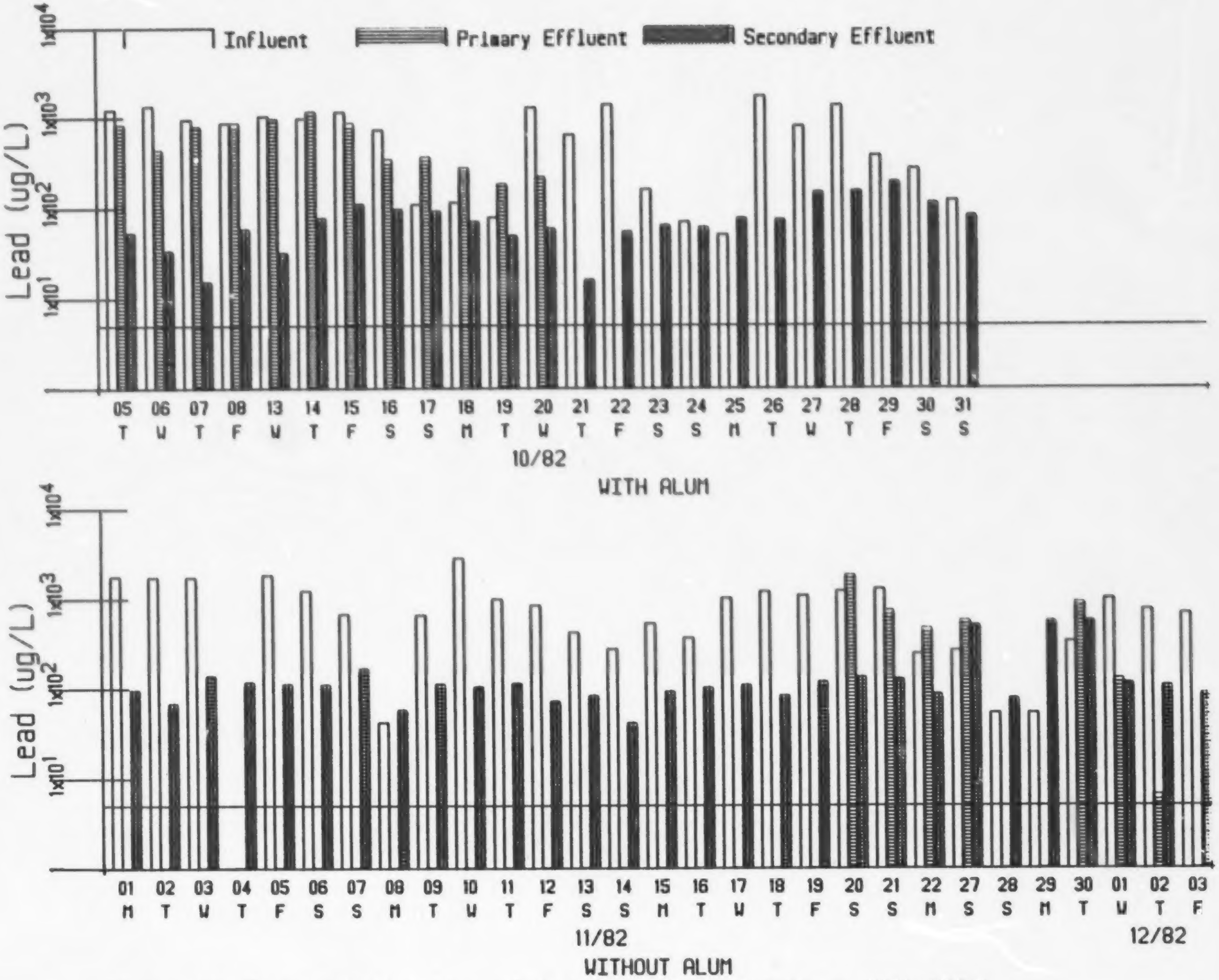
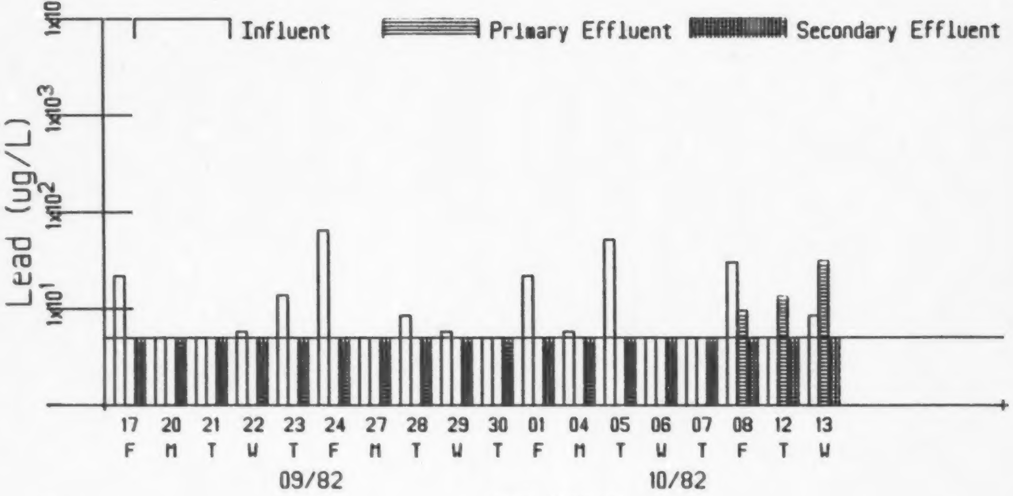
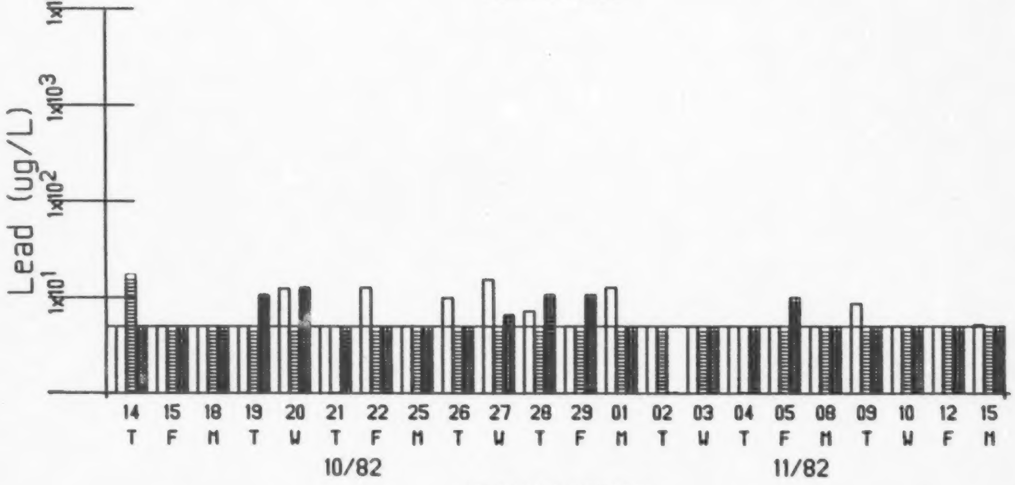


Figure 55 Temporal Variation of Total Lead at Fitchburg (MA) POTW

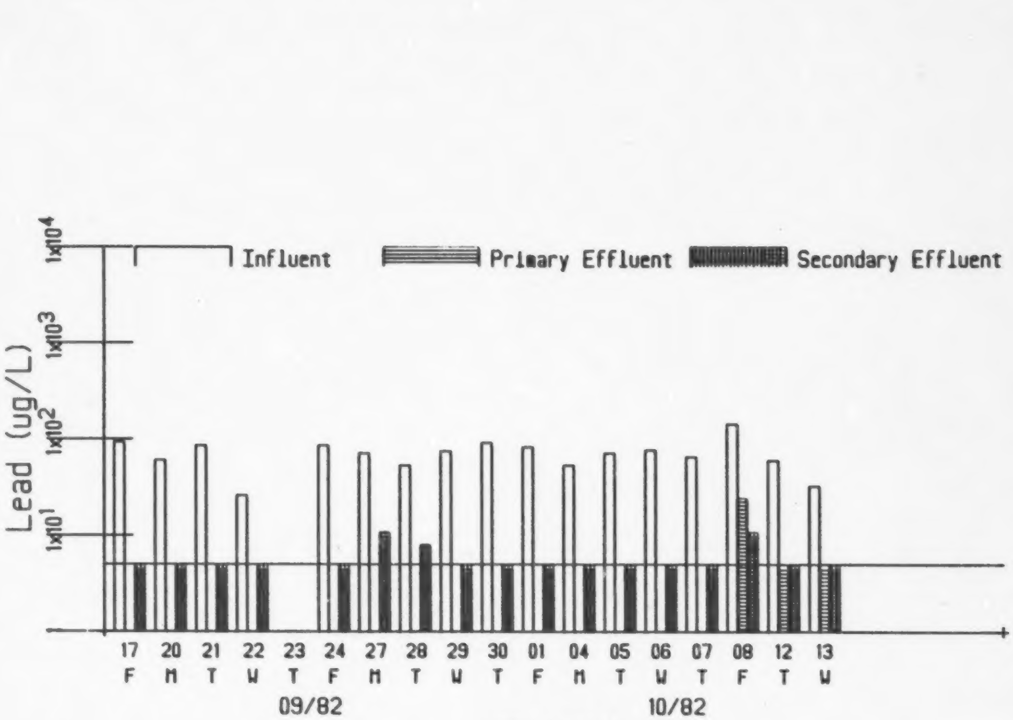


WITH NaA102

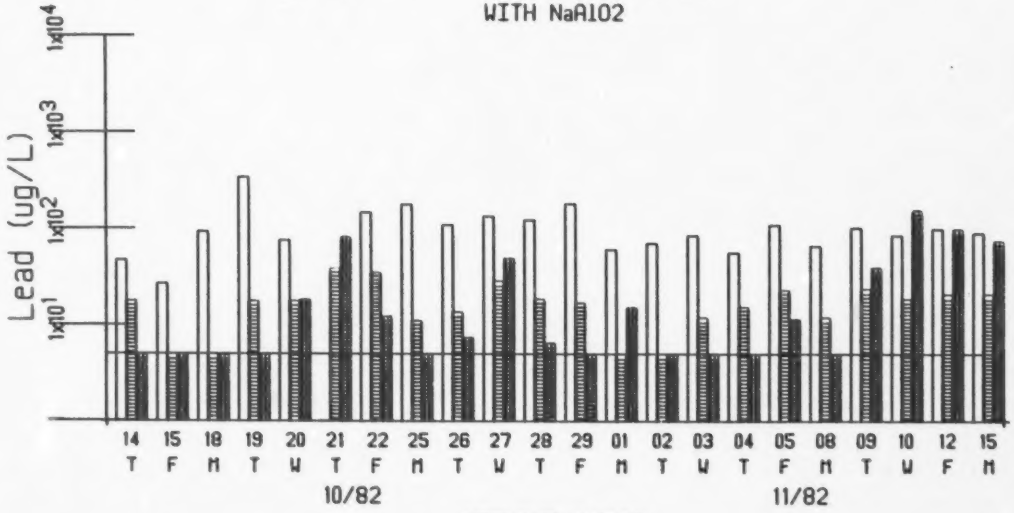


WITHOUT NaA102

Figure 56 Temporal Variation of Soluble Lead at Pittsfield (MA) POTW



WITH NaAl02



WITHOUT NaAl02

Figure 57 Temporal Variation of Total Lead at Pittsfield (MA) POTW

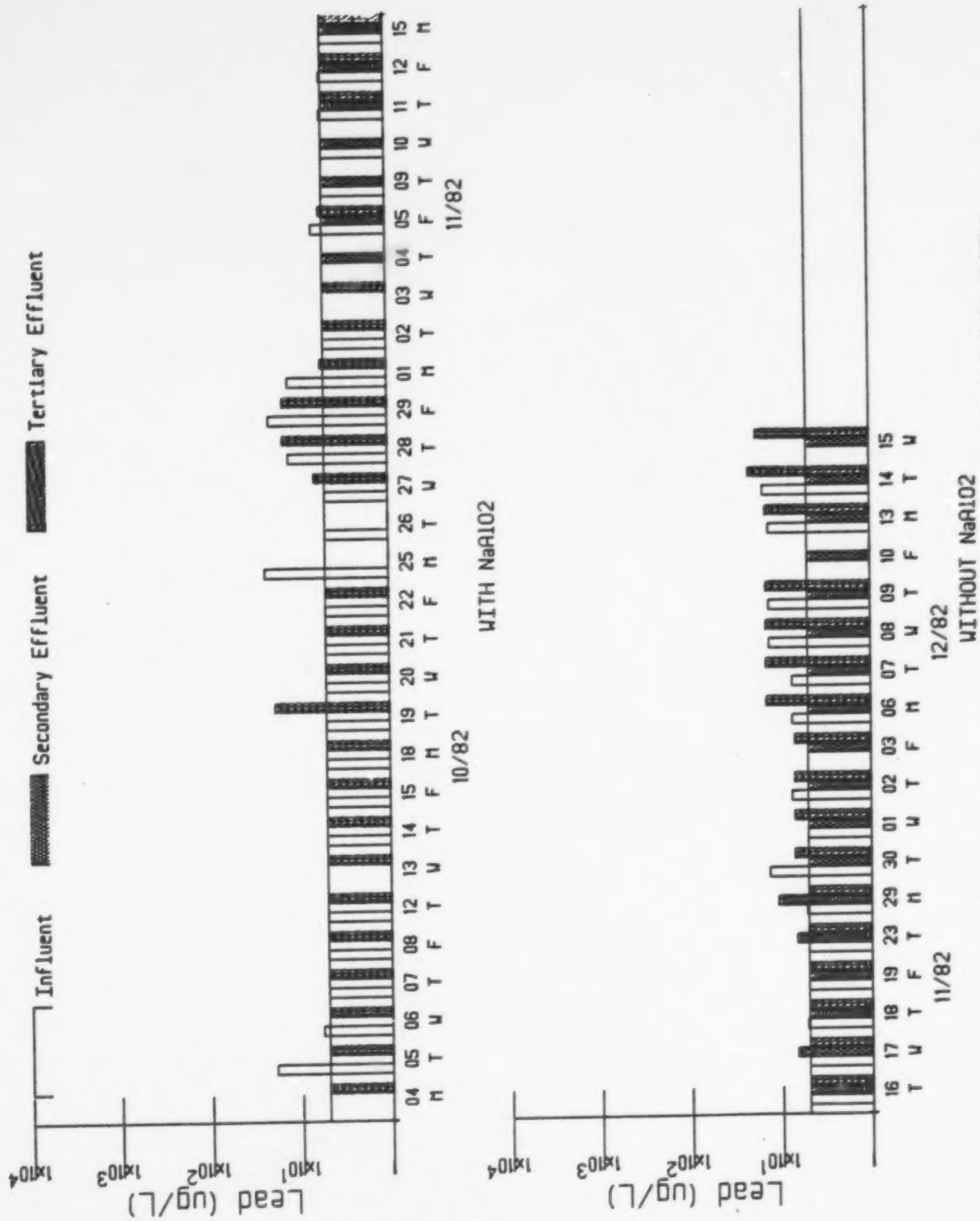


Figure 58 Temporal Variation of Soluble Lead at Medfield (MA) POTW

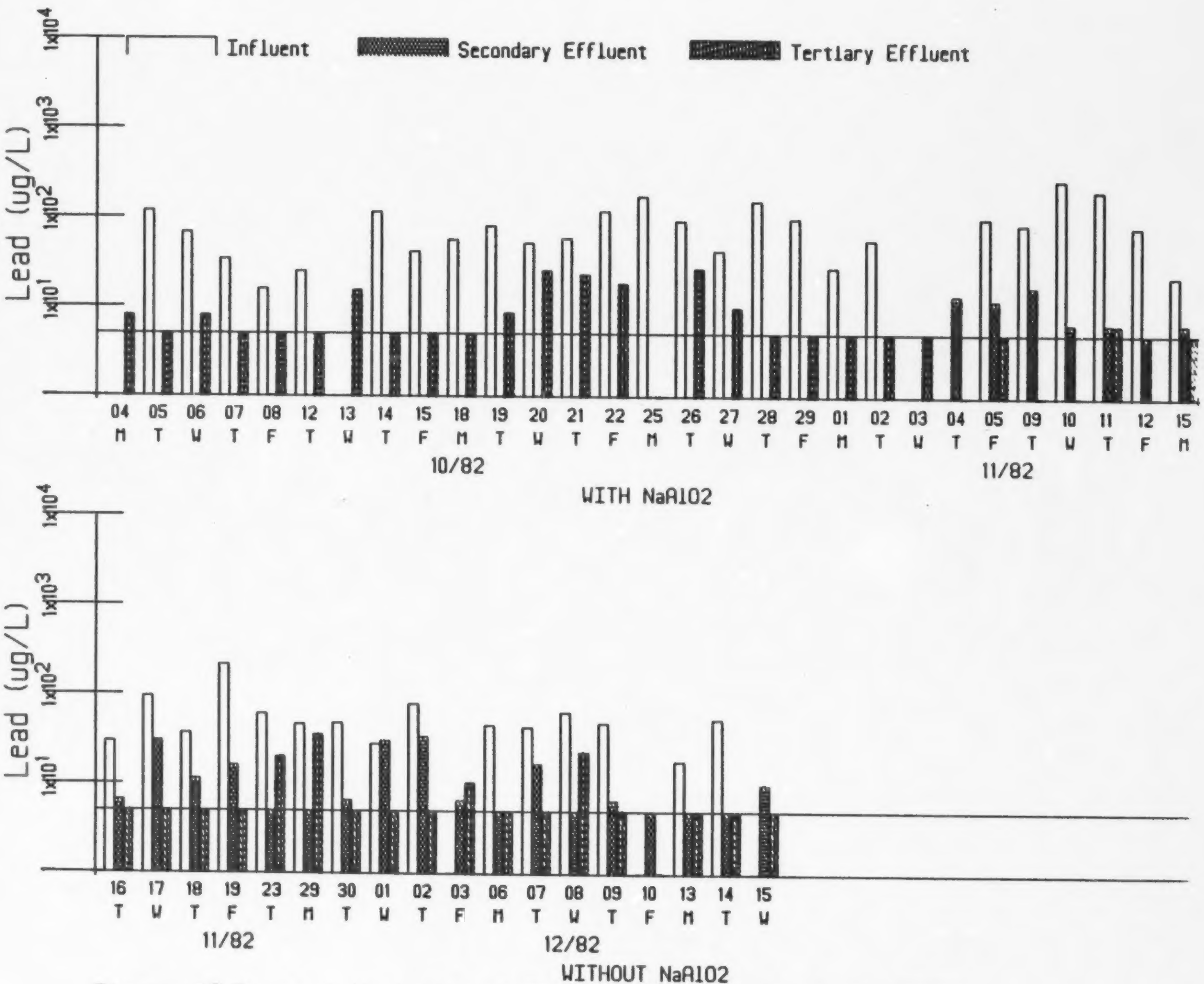


Figure 59 Temporal Variation of Total Lead at Medfield (MA) POTW

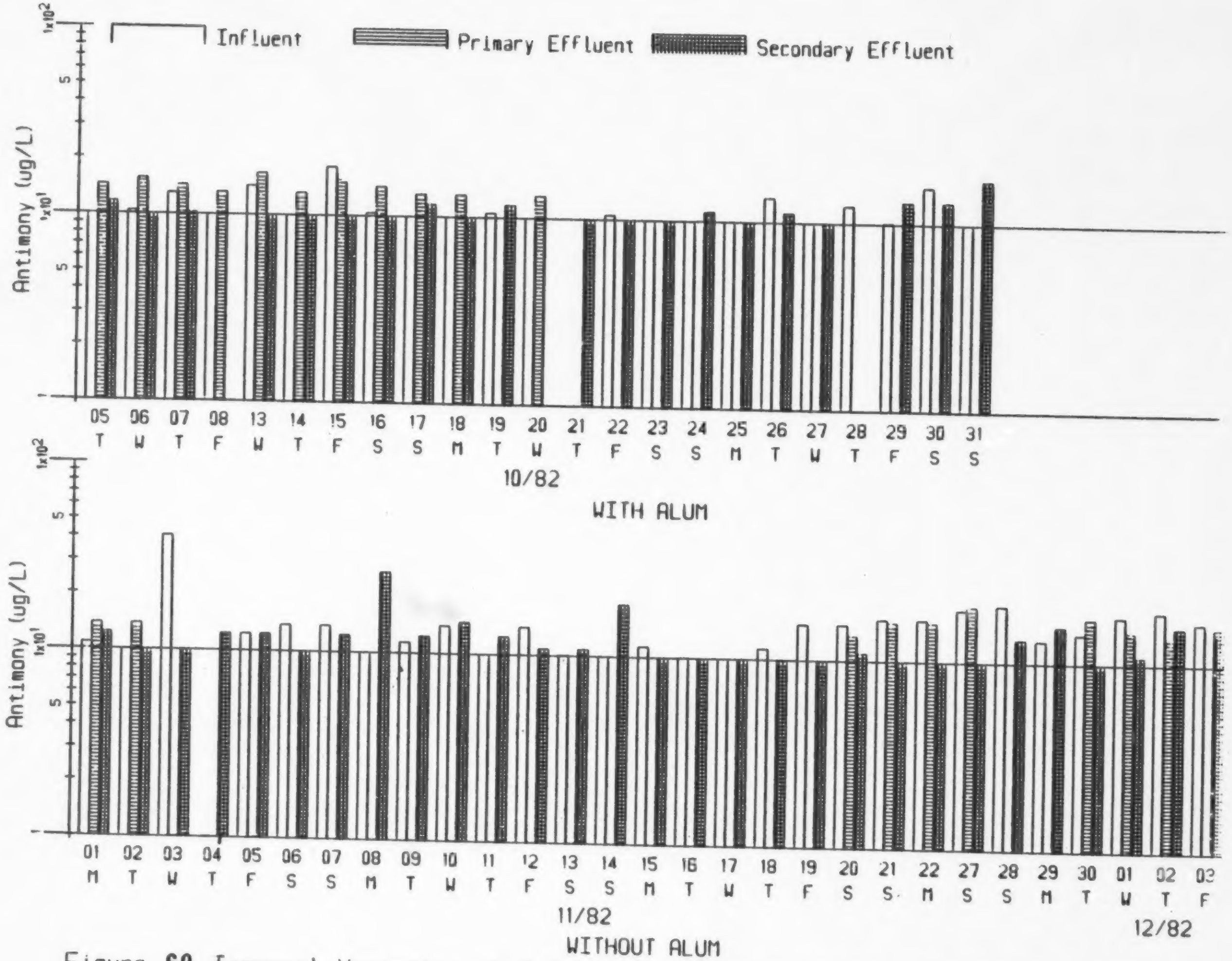


Figure **60** Temporal Variation of Soluble Antimony at Fitchburg (MA) POTW

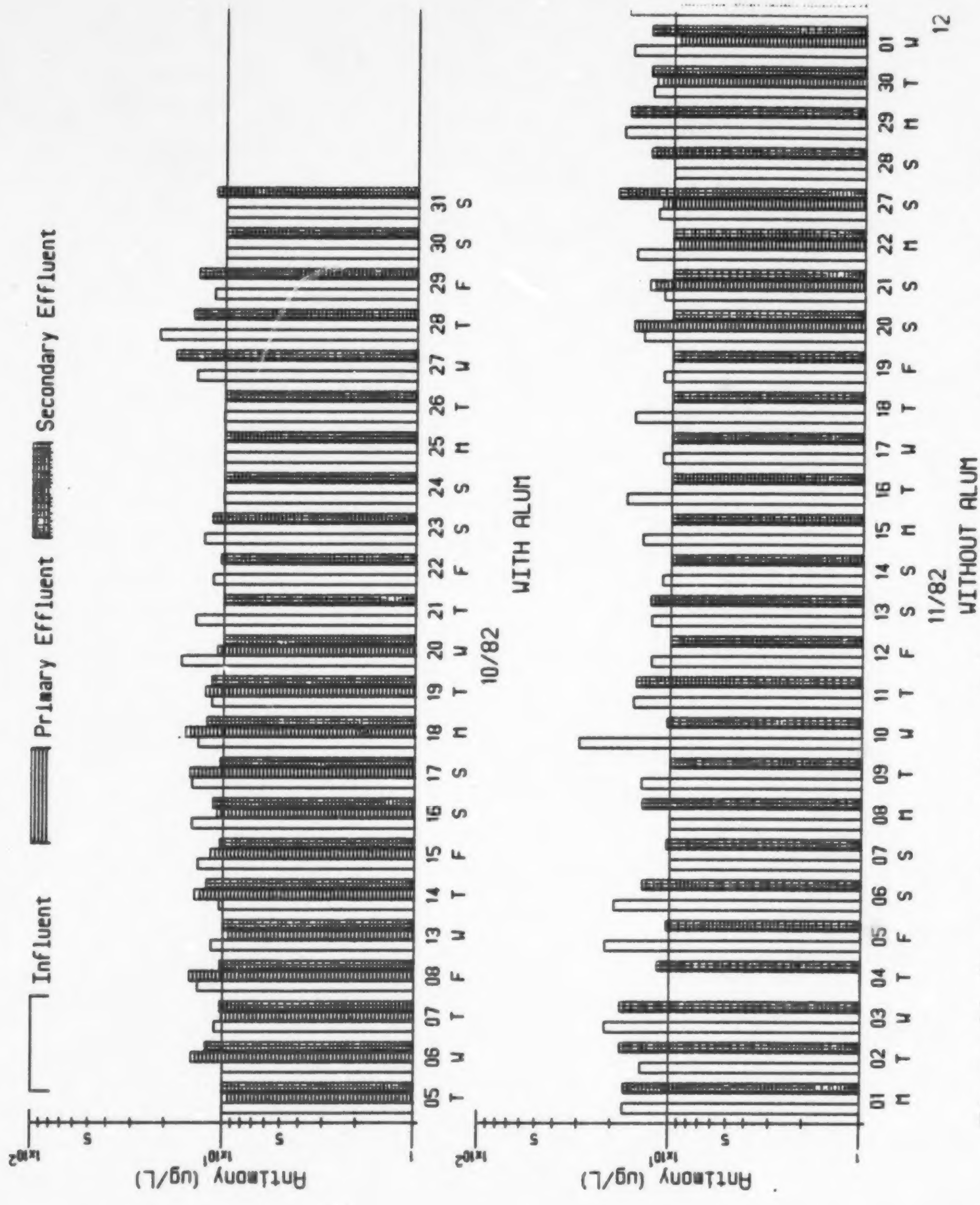


Figure 61 Temporal Variation of Total Antimony at Fitchburg (MA) POTW

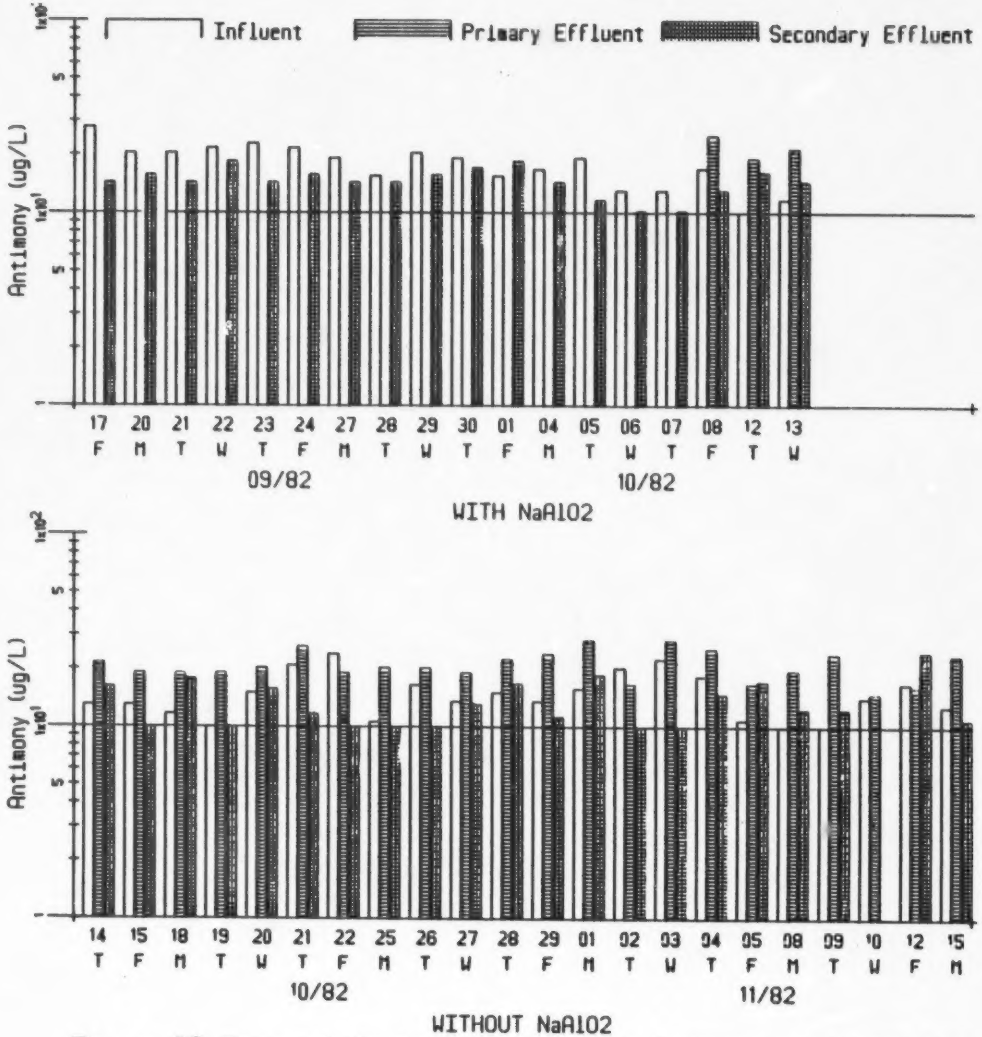
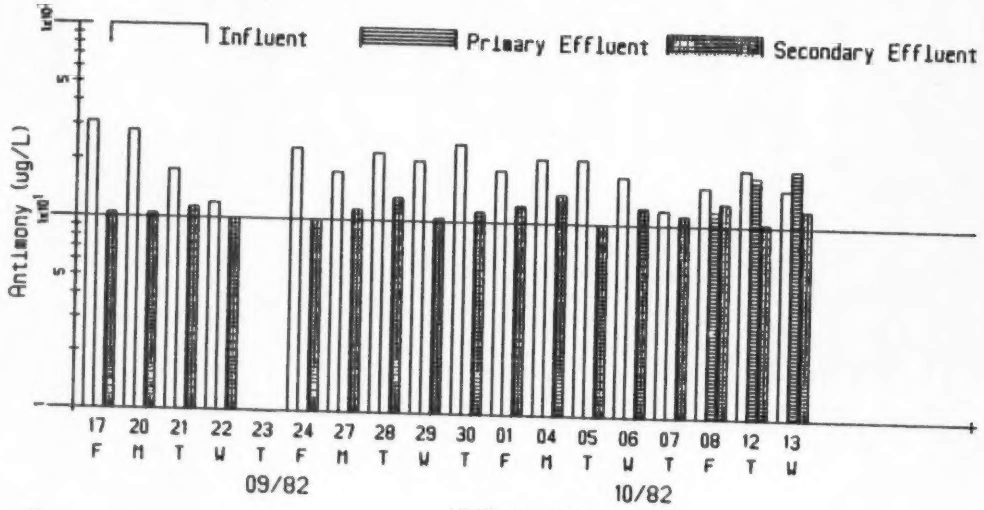
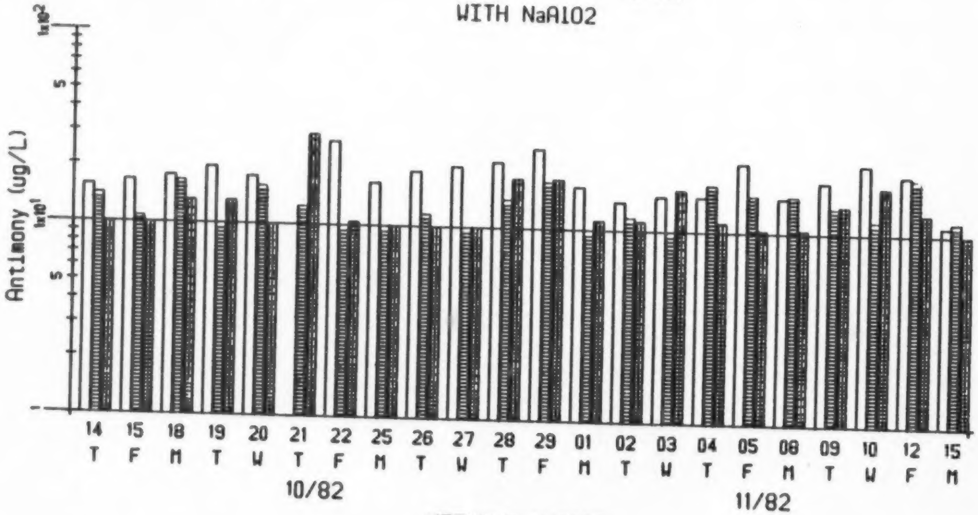


Figure 62 Temporal Variation of Soluble Antimony at Pittsfield (MA) POTW

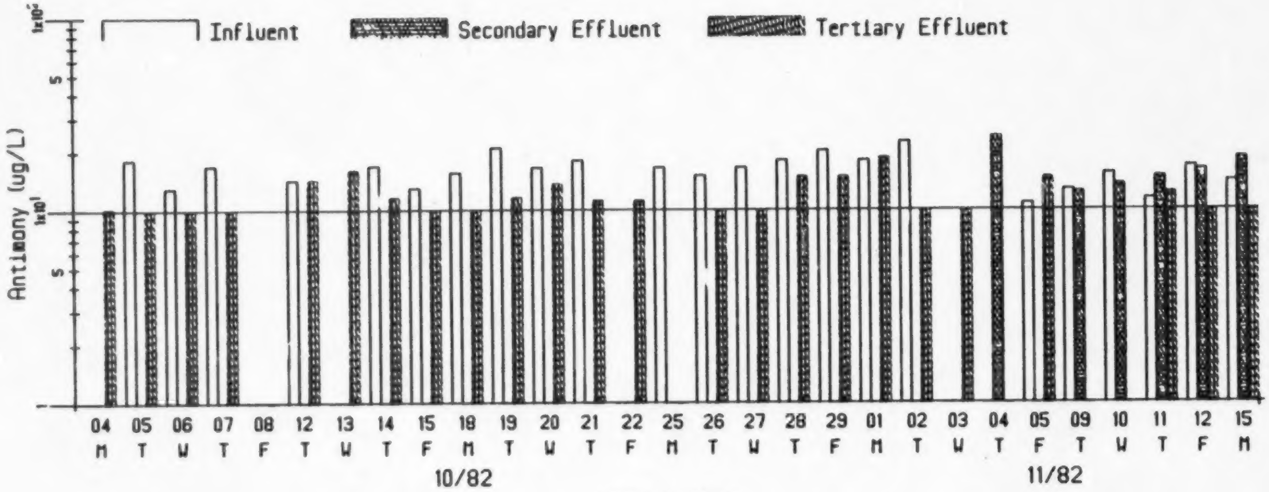


WITH NaAlO2

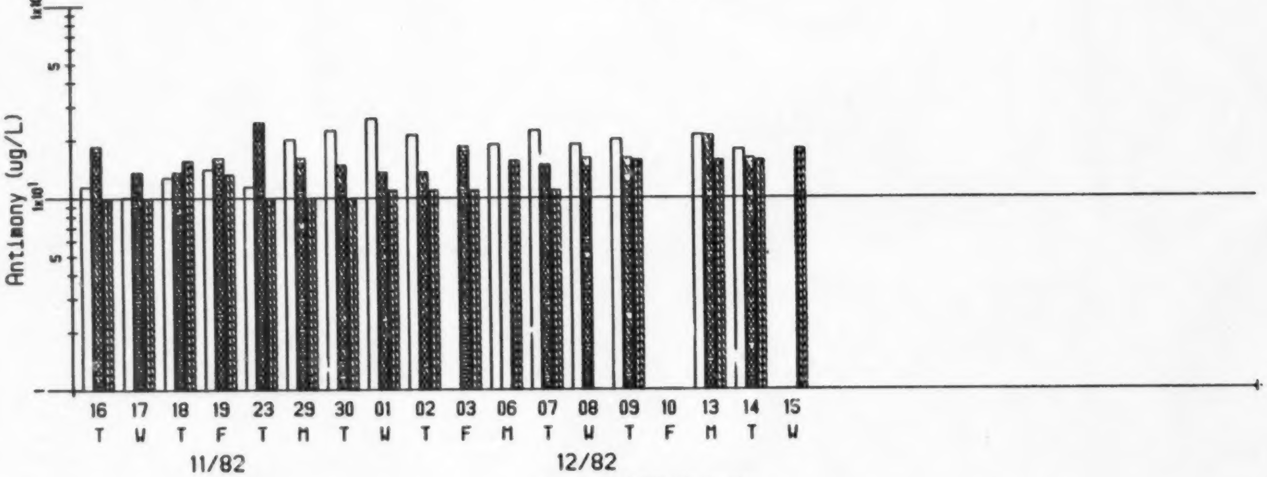


WITHOUT NaAlO2

Figure 63 Temporal Variation of Total Antimony at Pittsfield (MA) POTW



WITH NaAl02



WITHOUT NaAl02

Figure 64 Temporal Variation of Soluble Antimony at Medfield (MA) POTW

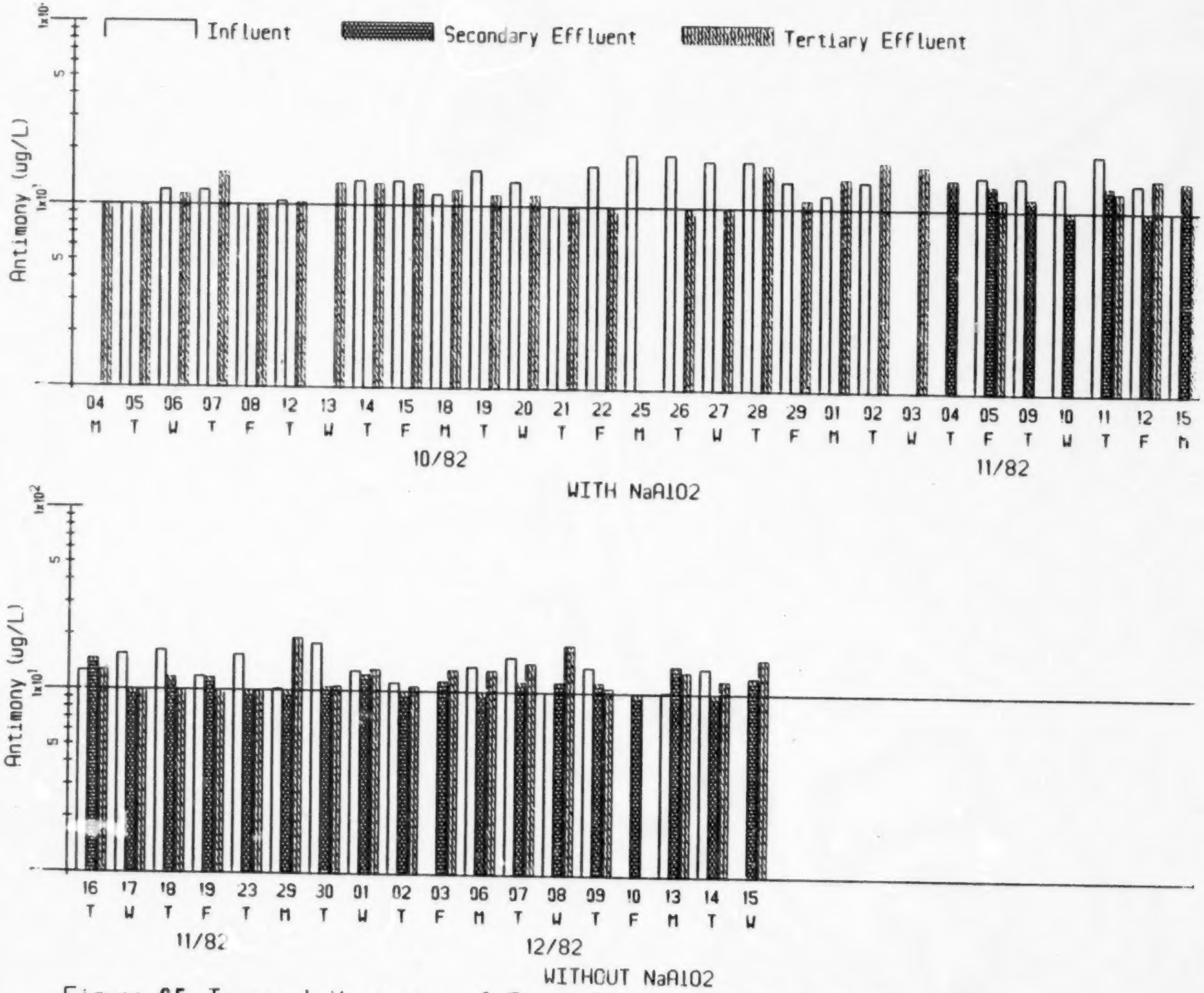


Figure 65 Temporal Variation of Total Antimony at Medfield (MA) POTW

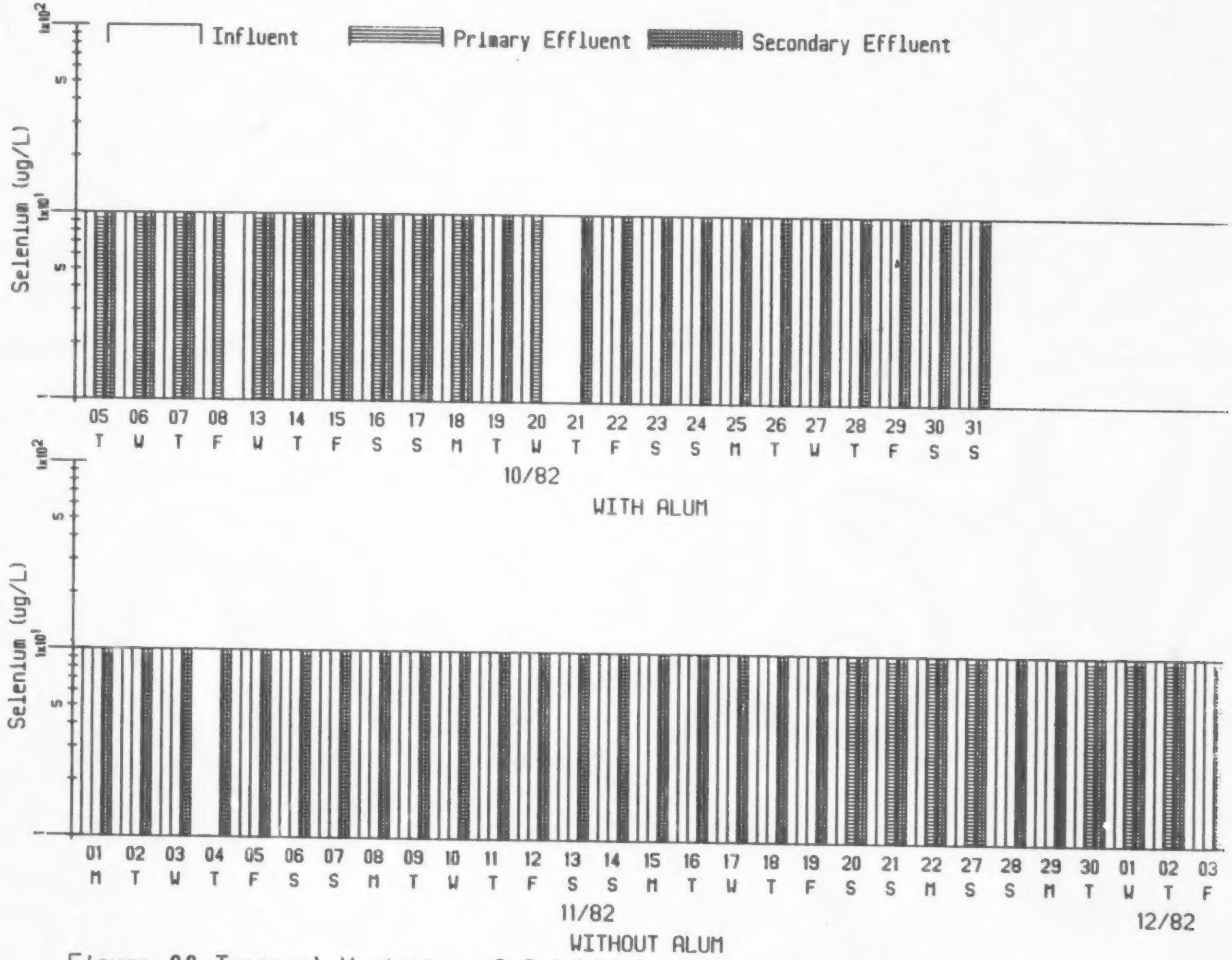


Figure **66** Temporal Variation of Soluble Selenium at Fitchburg (MA) POTW

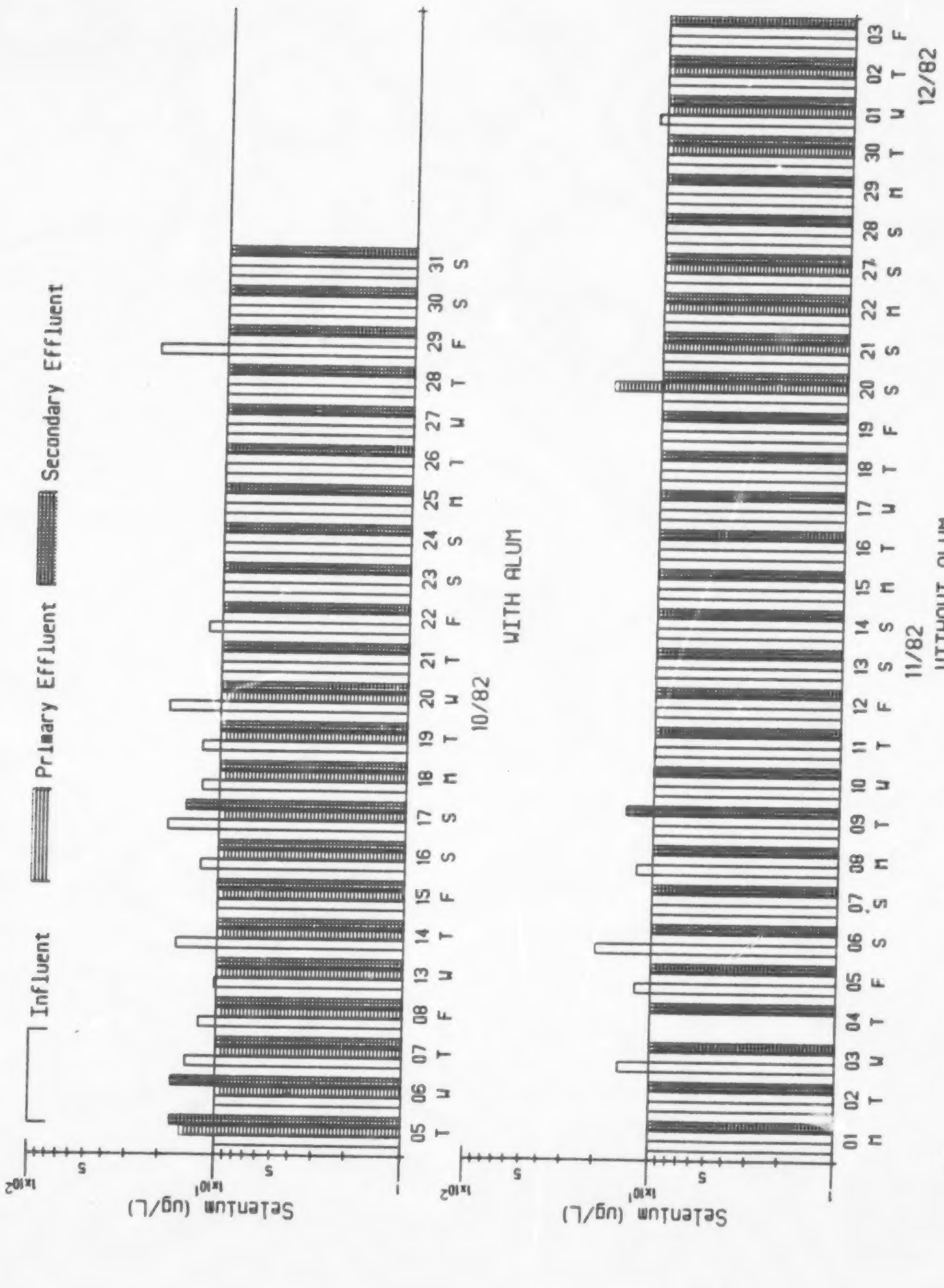
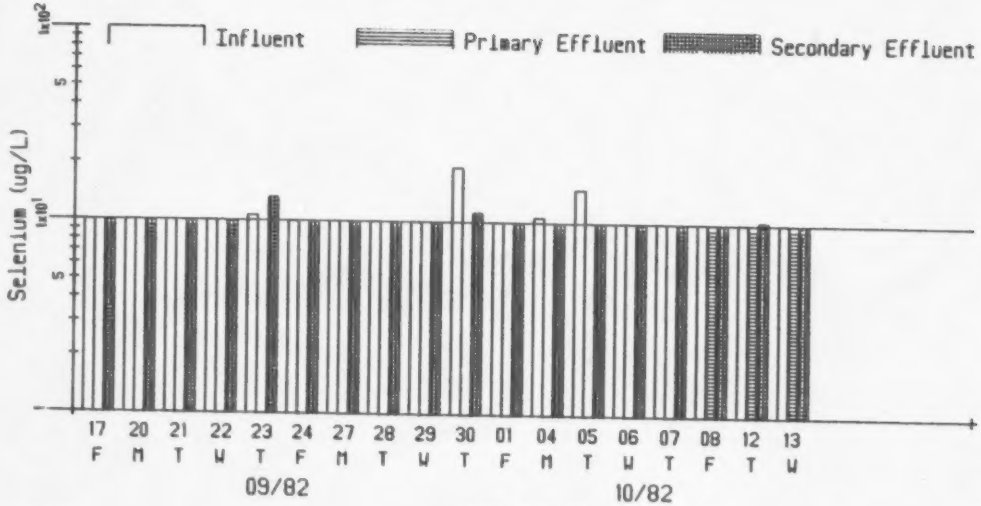
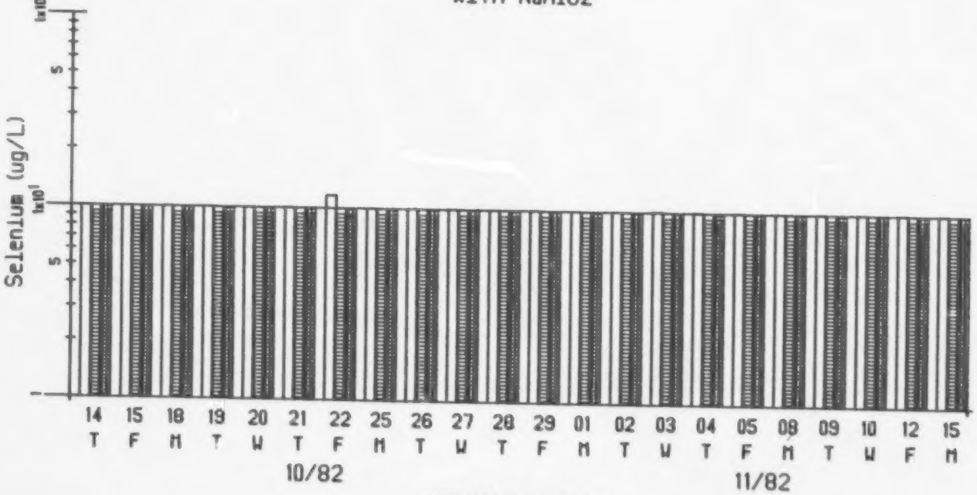


Figure 67 Temporal Variation of Total Selenium at Fitchburg (MA) POTW



WITH NaAl02



WITHOUT NaAl02

Figure 68 Temporal Variation of Soluble Selenium at Pittsfield (MA) POTW

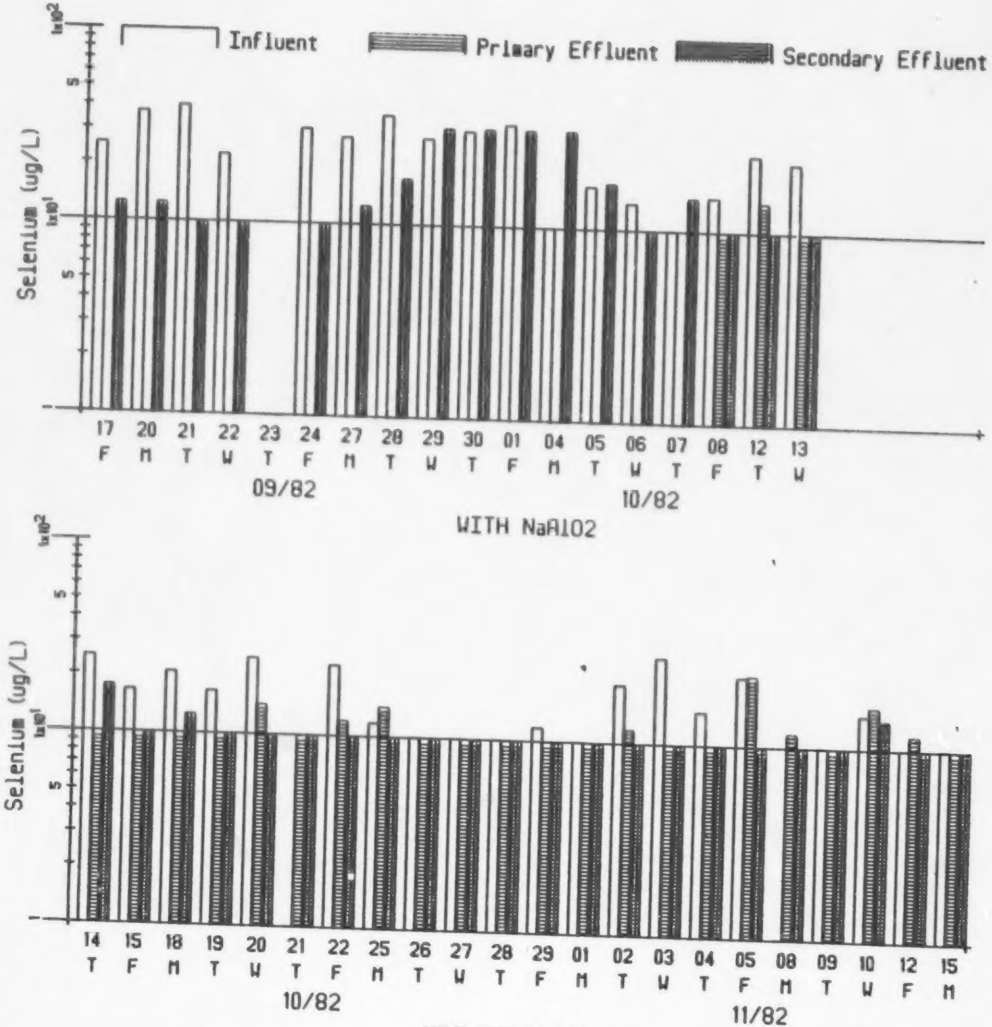


Figure 69 Temporal Variation of Total Selenium at Pittsfield (MA) POTW

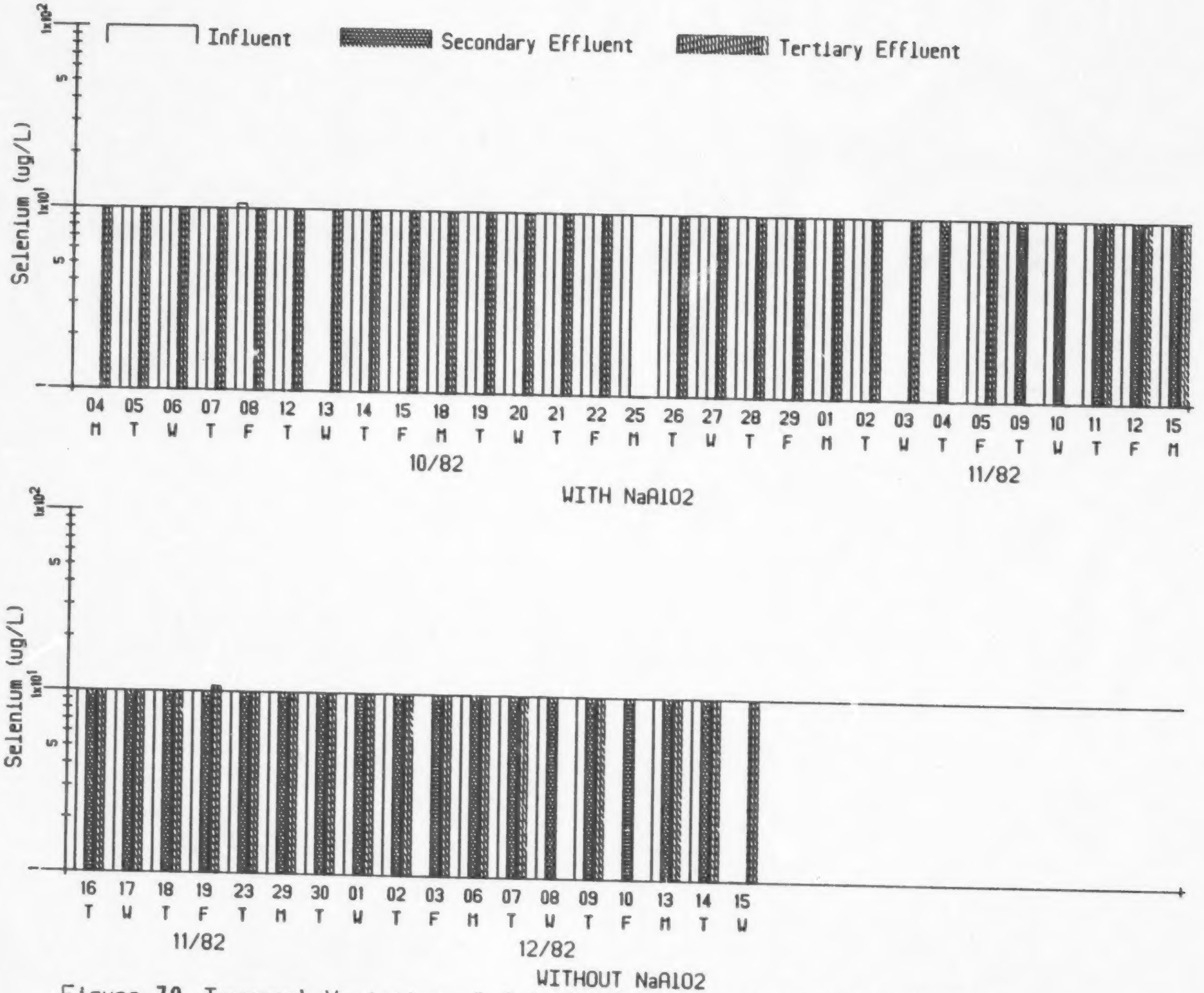


Figure **70** Temporal Variation of Soluble Selenium at Medfield (MA) POTW

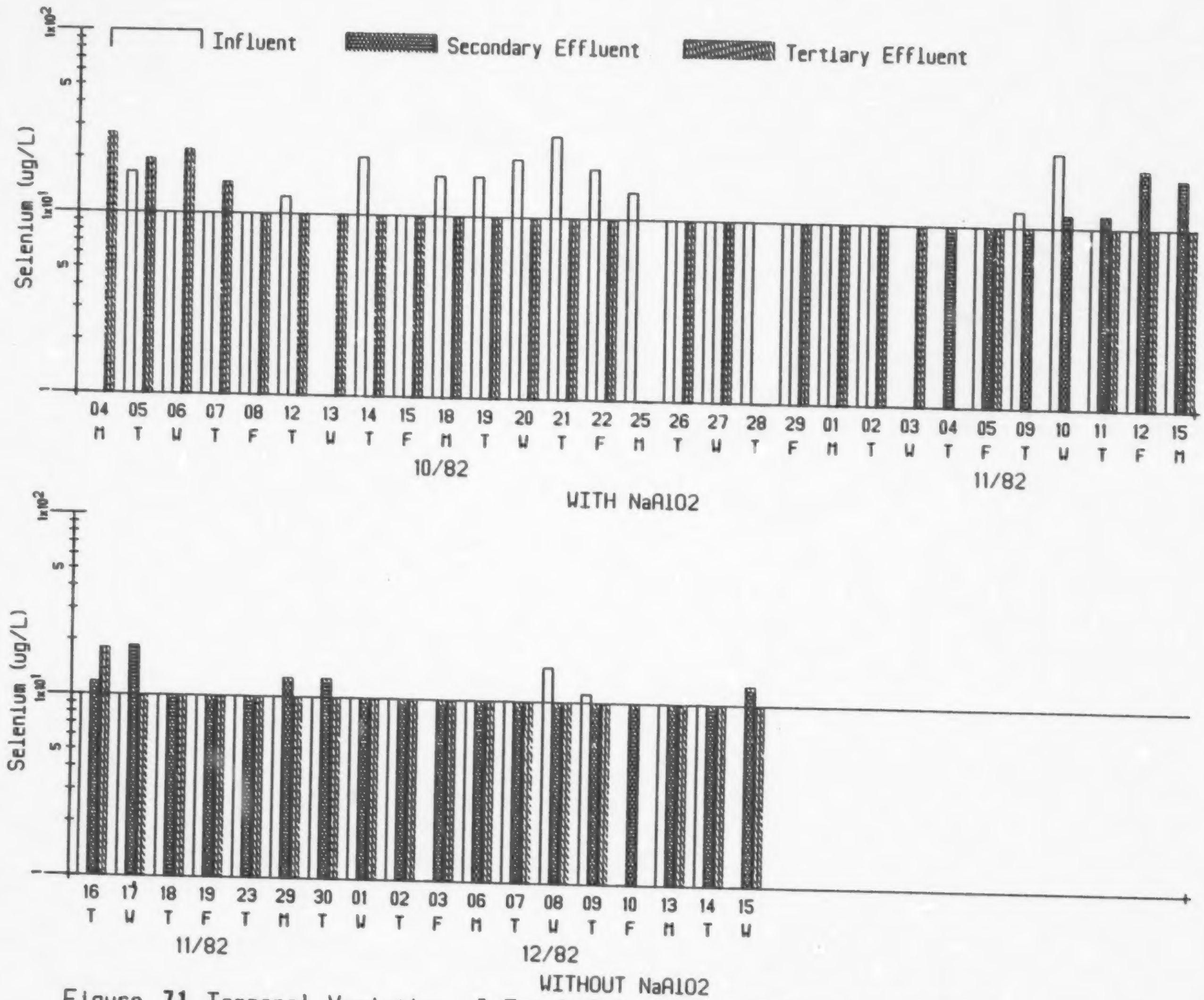


Figure 71 Temporal Variation of Total Selenium at Medfield (MA) POTW

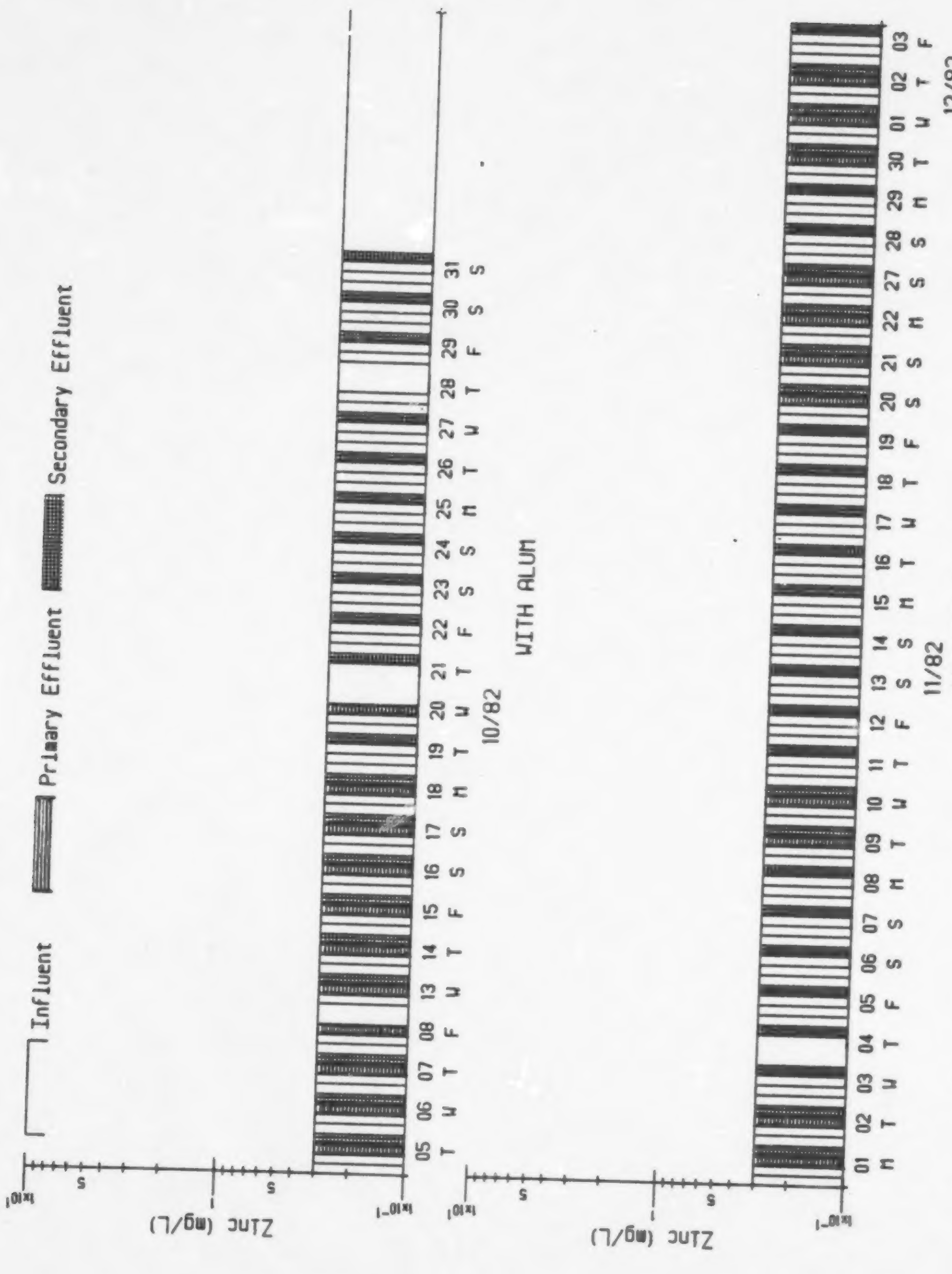


Figure 72 Temporal Variation of Soluble Zinc at Fitchburg (MA) POTW

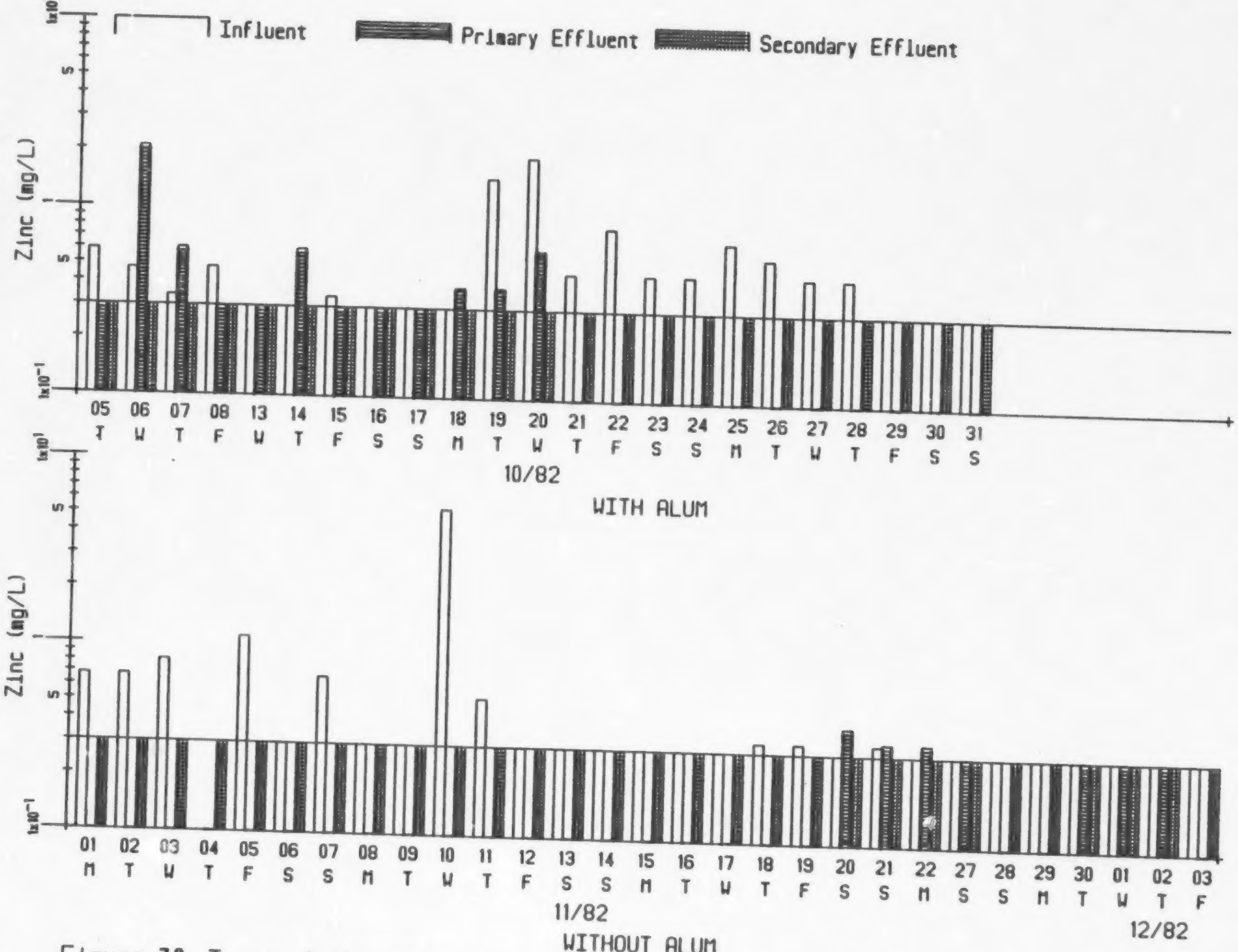
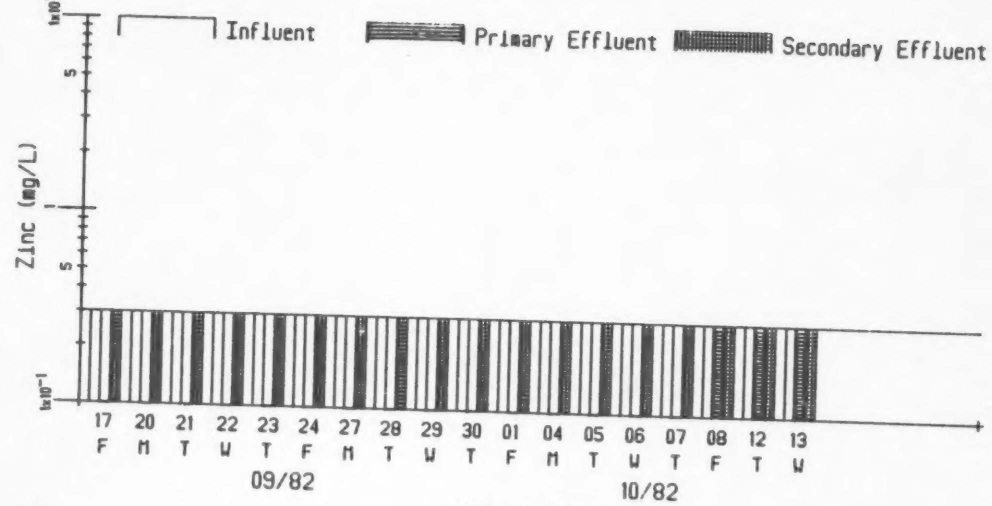
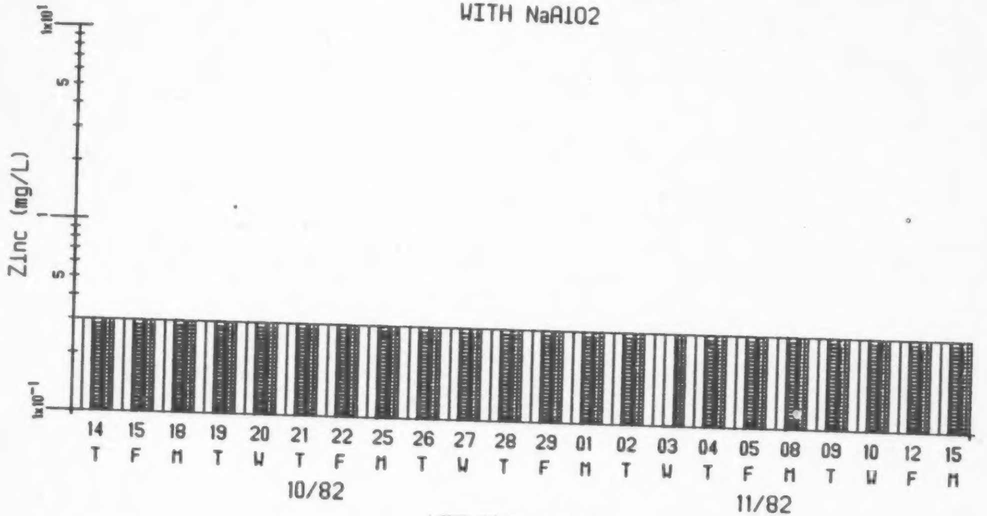


Figure **73** Temporal Variation of Total Zinc at Fitchburg (MA) POTW

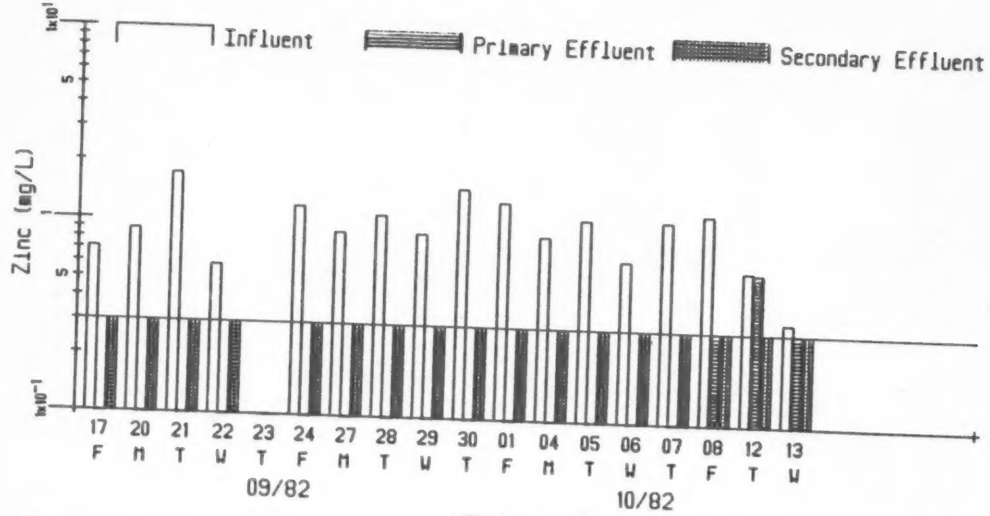


WITH NaAl02

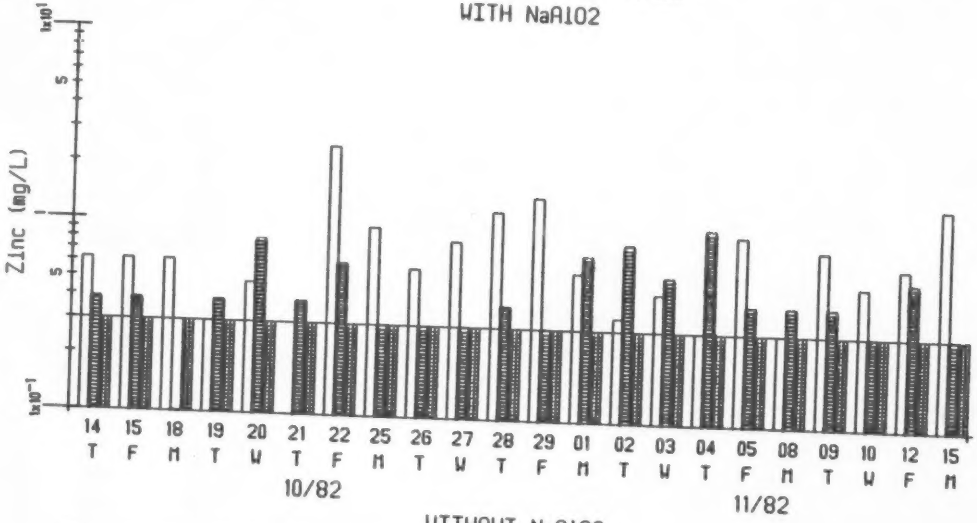


WITHOUT NaAl02

Figure 74 Temporal Variation of Soluble Zinc at Pittsfield (MA) POTW



WITH NaAl02



WITHOUT NaAl02

Figure 75 Temporal Variation of Total Zinc at Pittsfield (MA) POTW

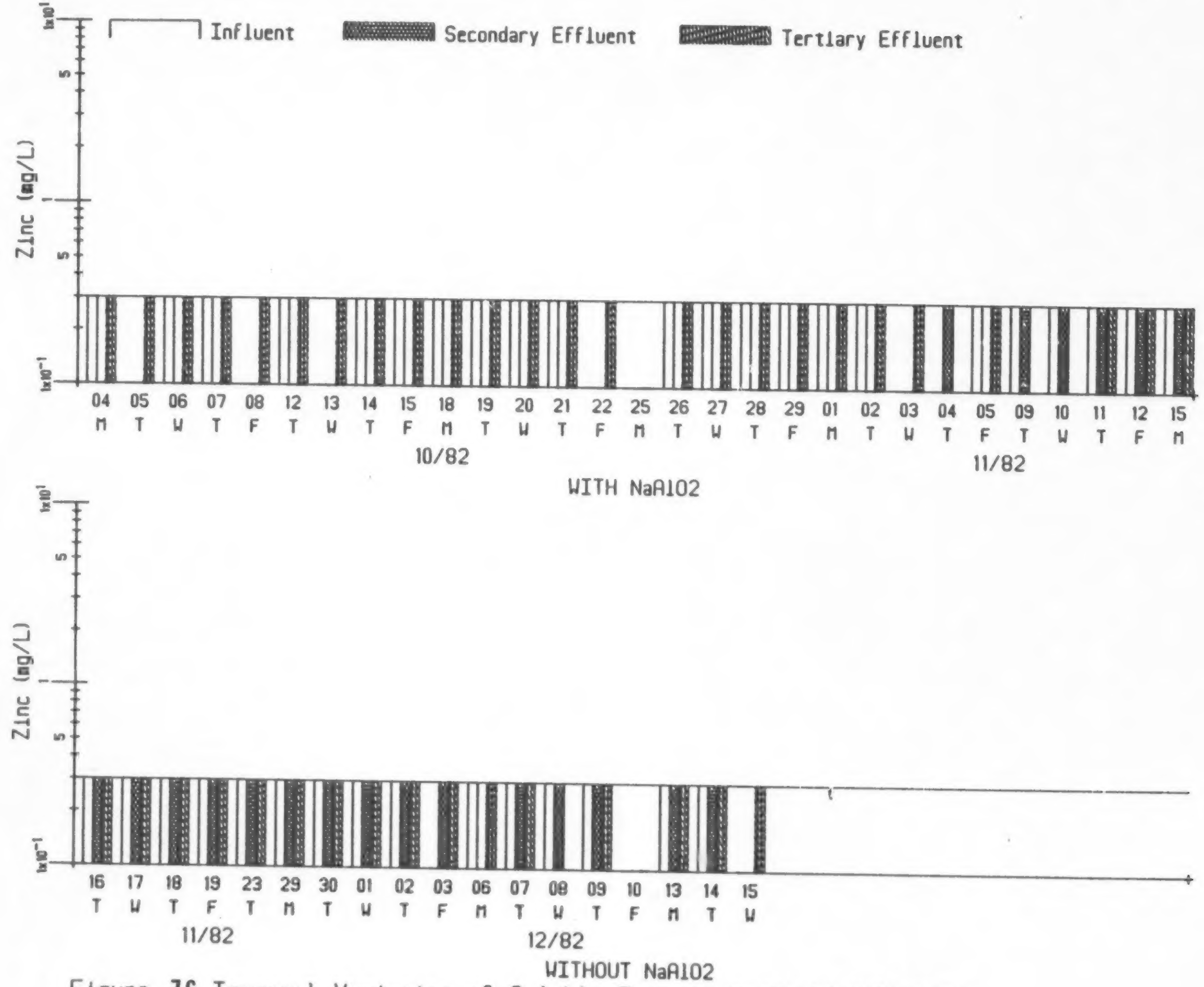


Figure **76** Temporal Variation of Soluble Zinc at Medfield (MA) POTW

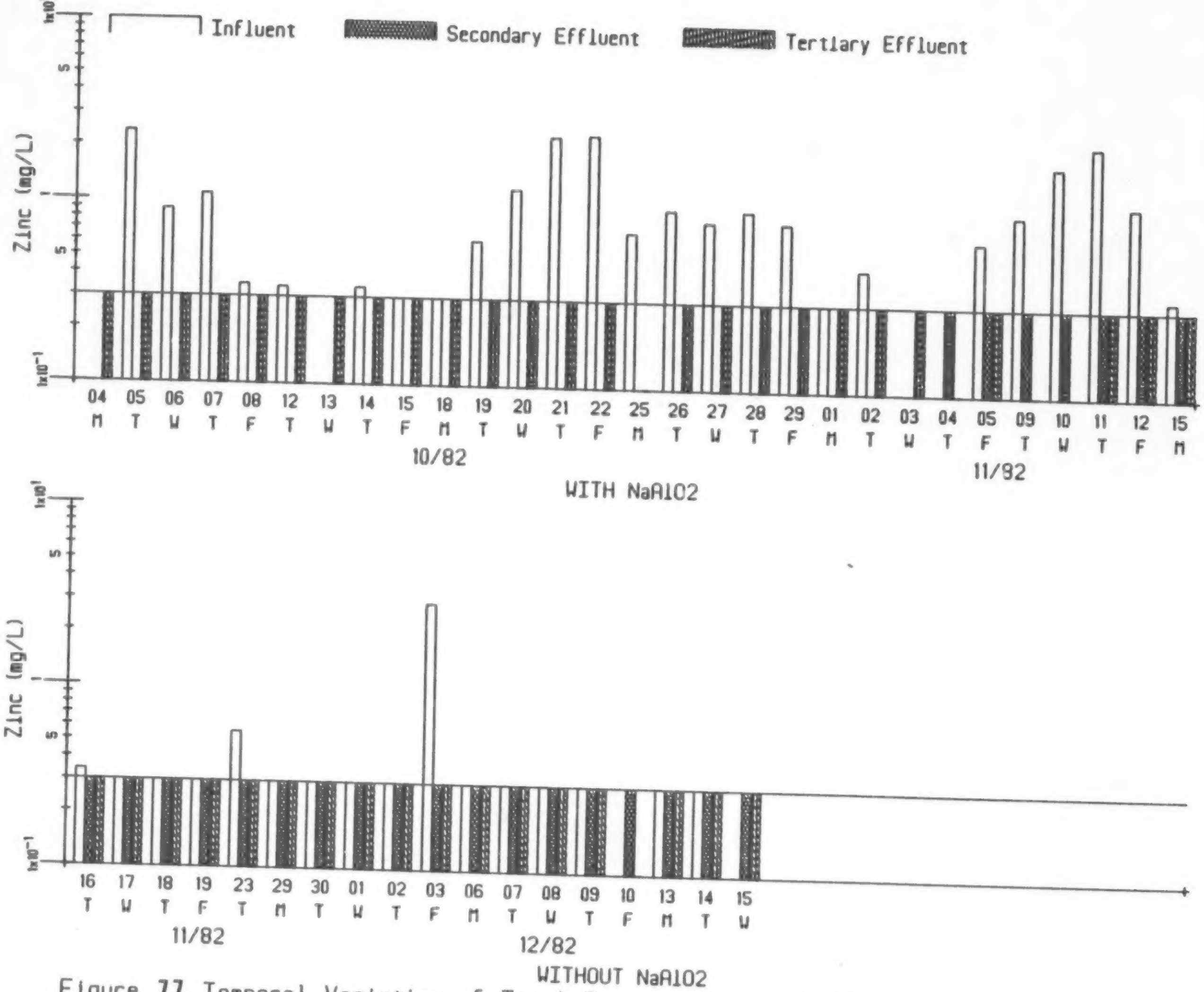


Figure 77 Temporal Variation of Total Zinc at Medfield (MA) POTW

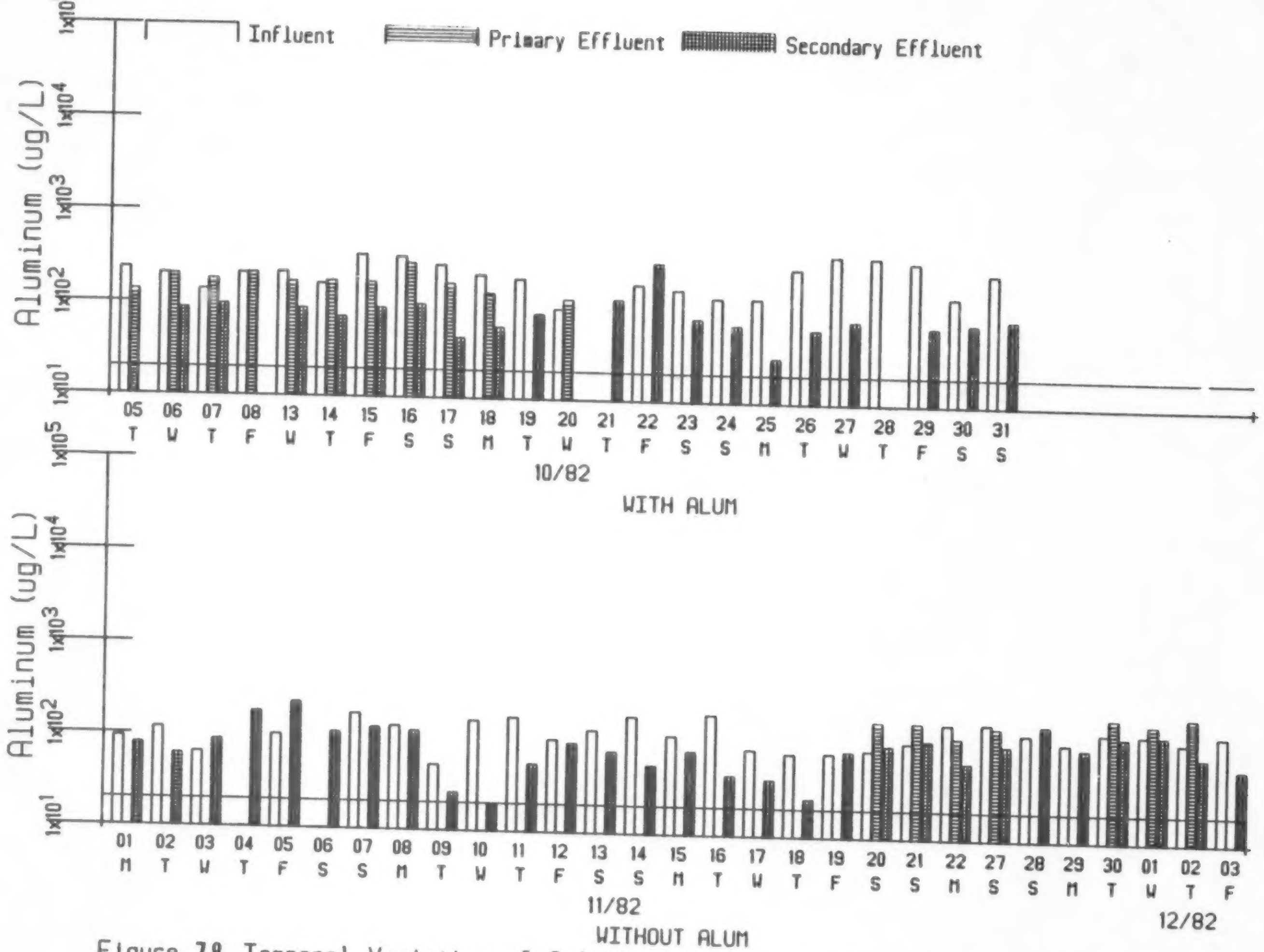


Figure 78 Temporal Variation of Soluble Aluminum at Fitchburg (MA) POTW

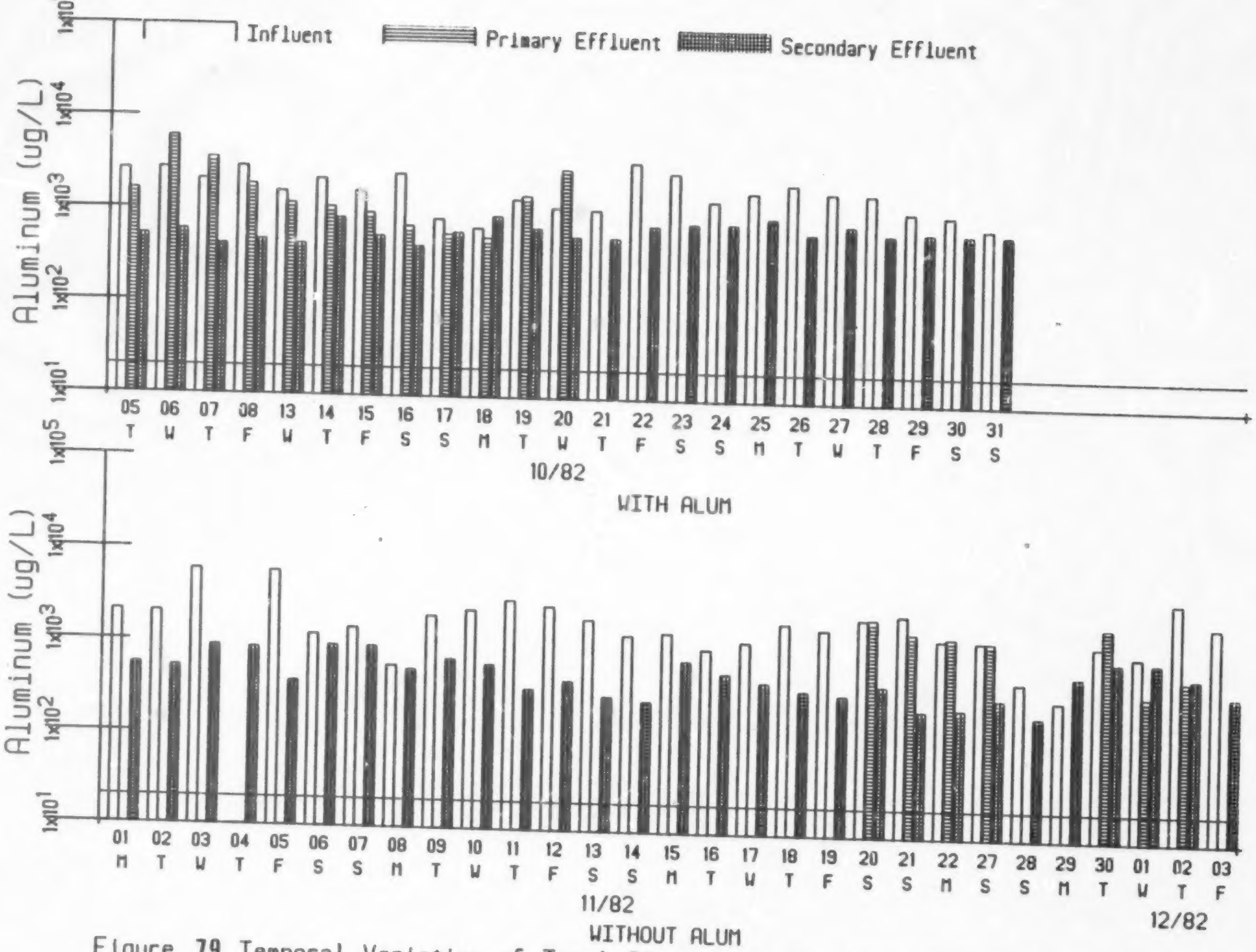


Figure 79 Temporal Variation of Total Aluminum at Fitchburg (MA) POTW

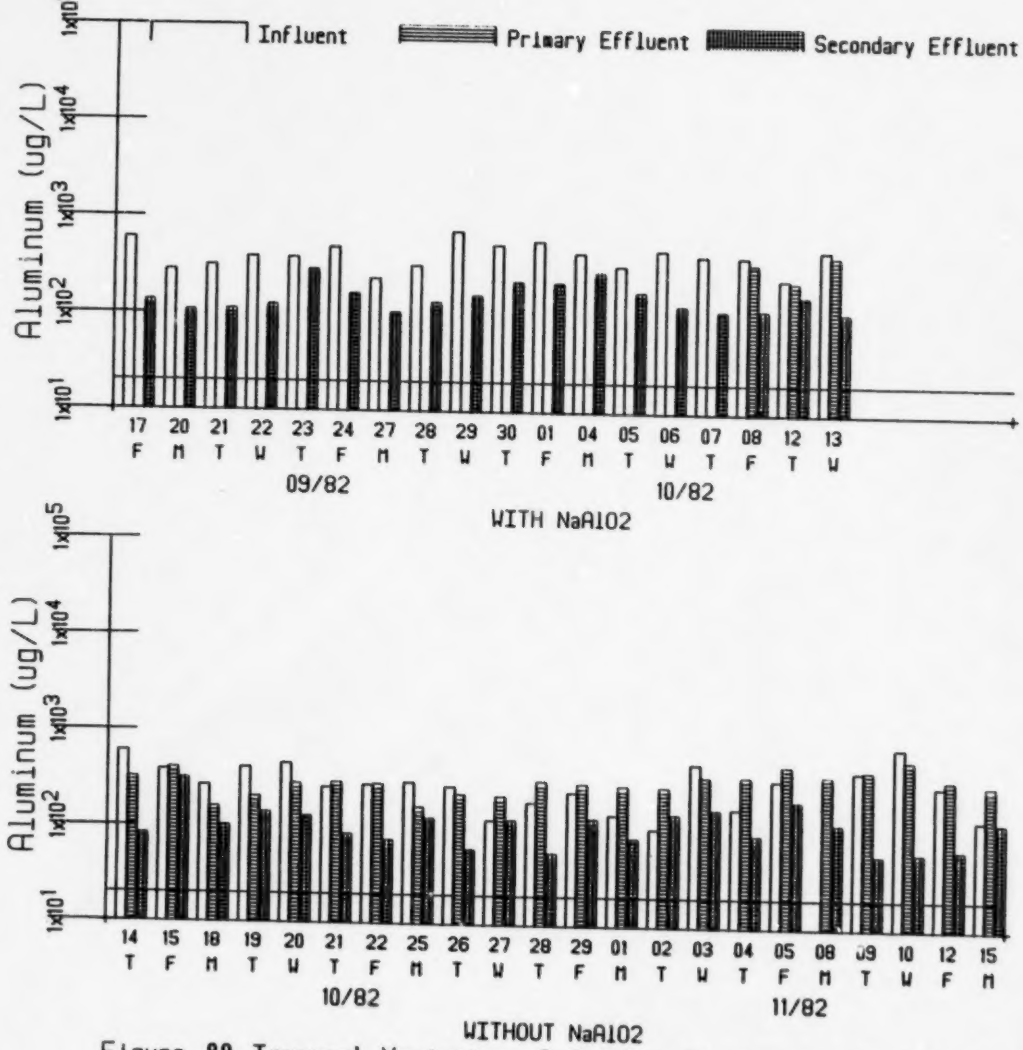


Figure 80 Temporal Variation of Soluble Aluminum at Pittsfield (MA) POTW

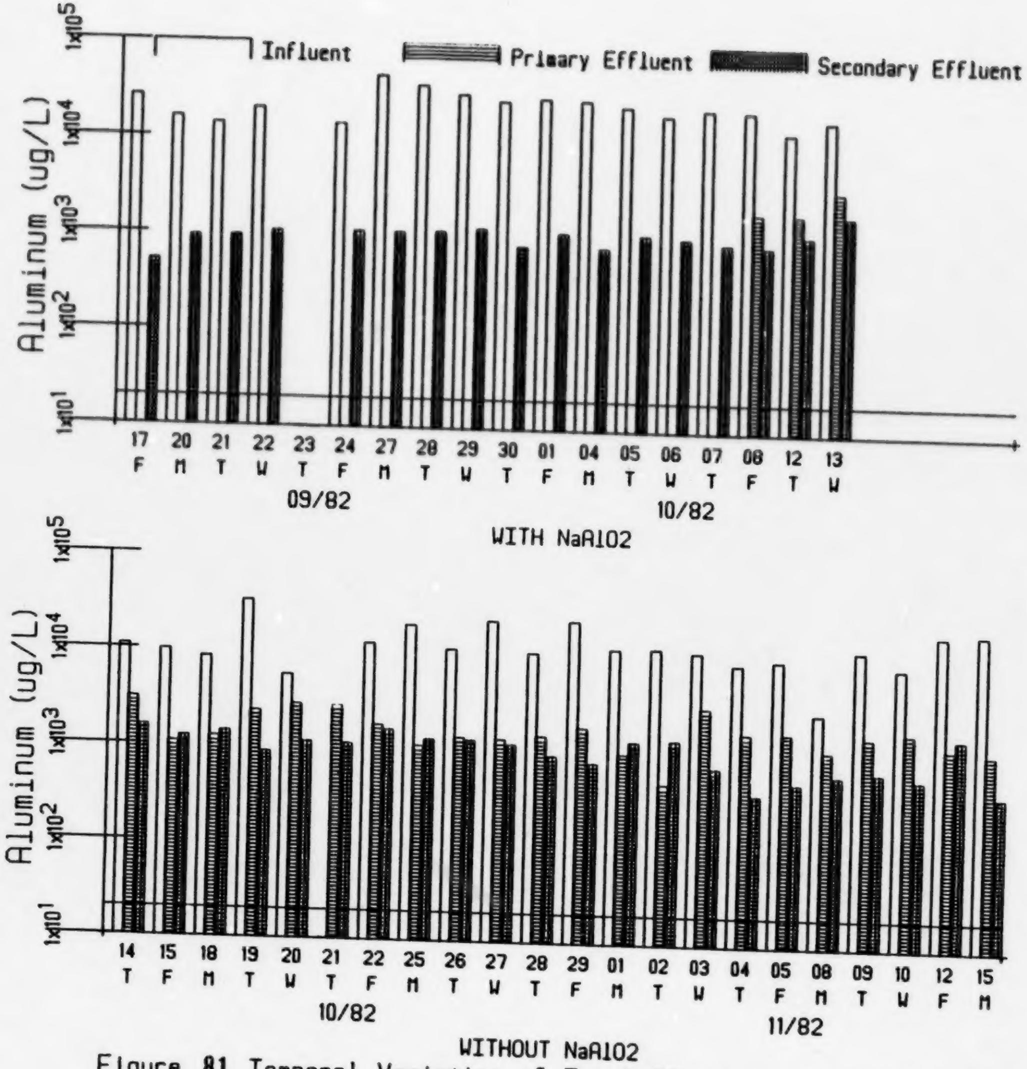


Figure 81 Temporal Variation of Total Aluminum at Pittsfield (MA) POTW

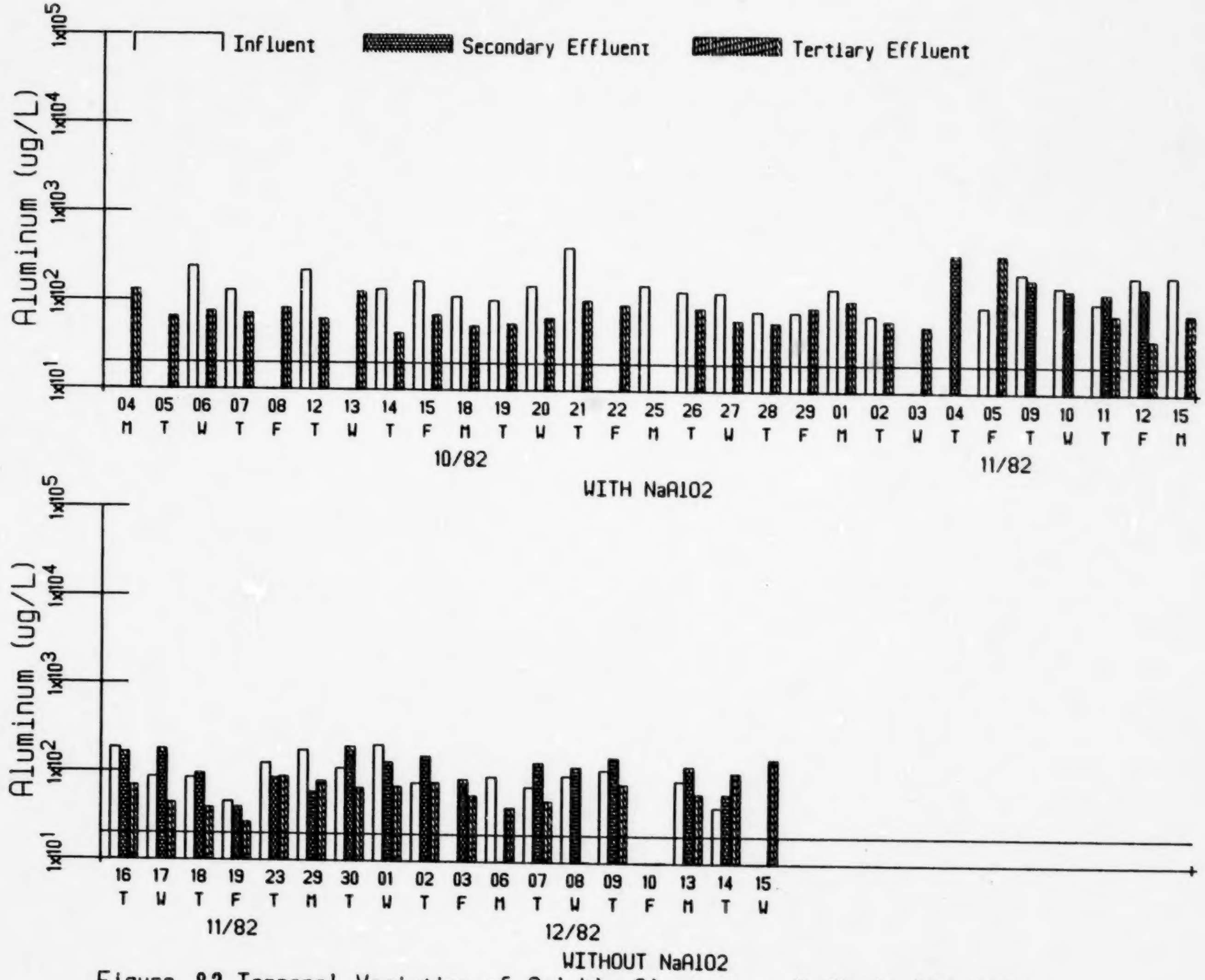
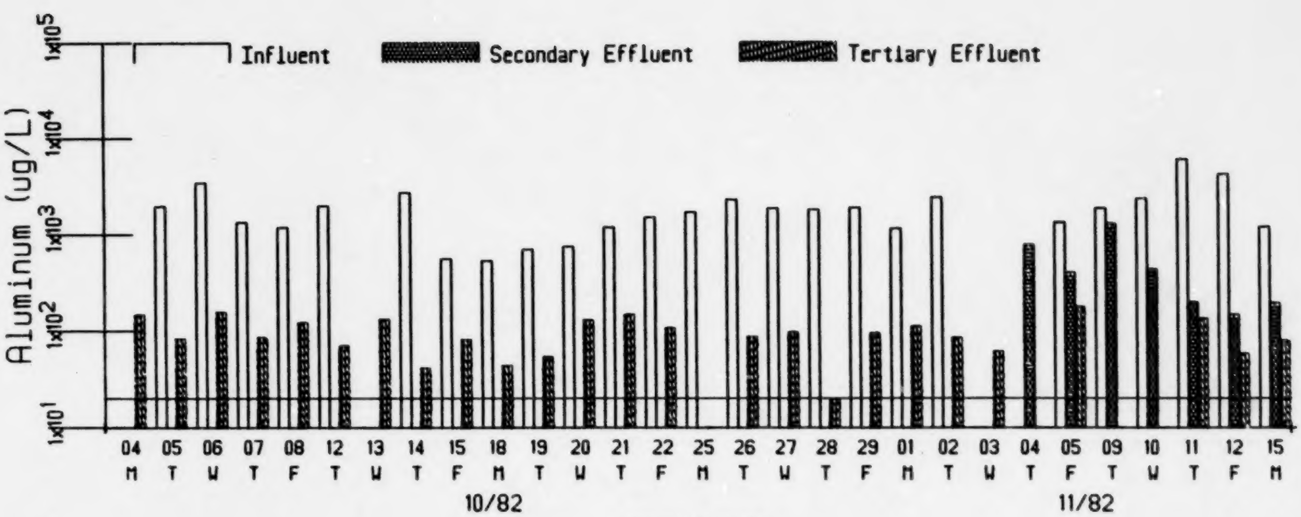
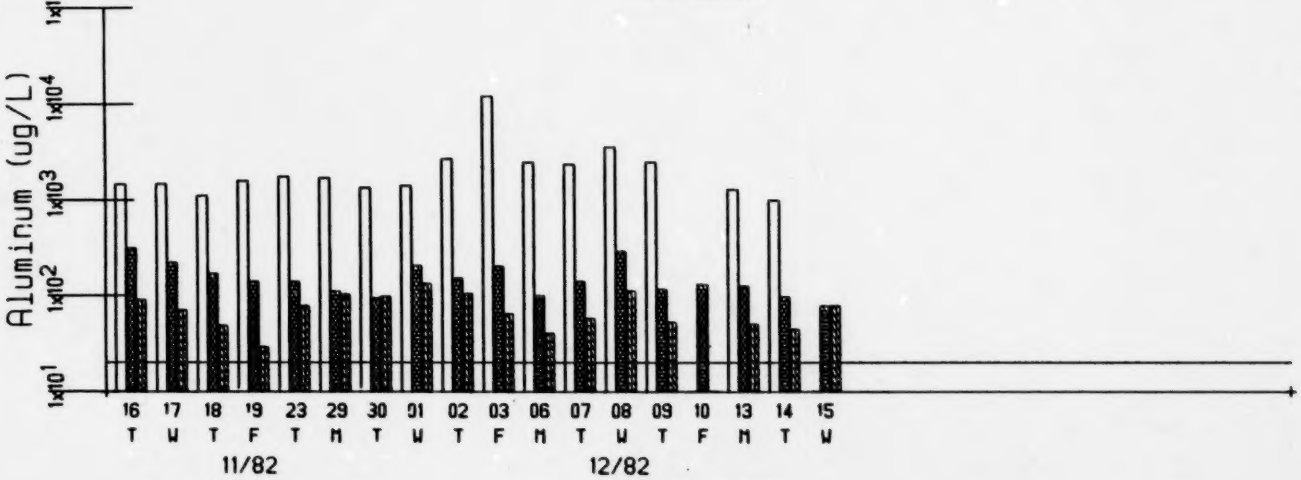


Figure 82 Temporal Variation of Soluble Aluminum at Medfield (MA) POTW



WITH NaAl02



WITHOUT NaAl02

Figure **83** Temporal Variation of Total Aluminum at Medfield (MA) POTW

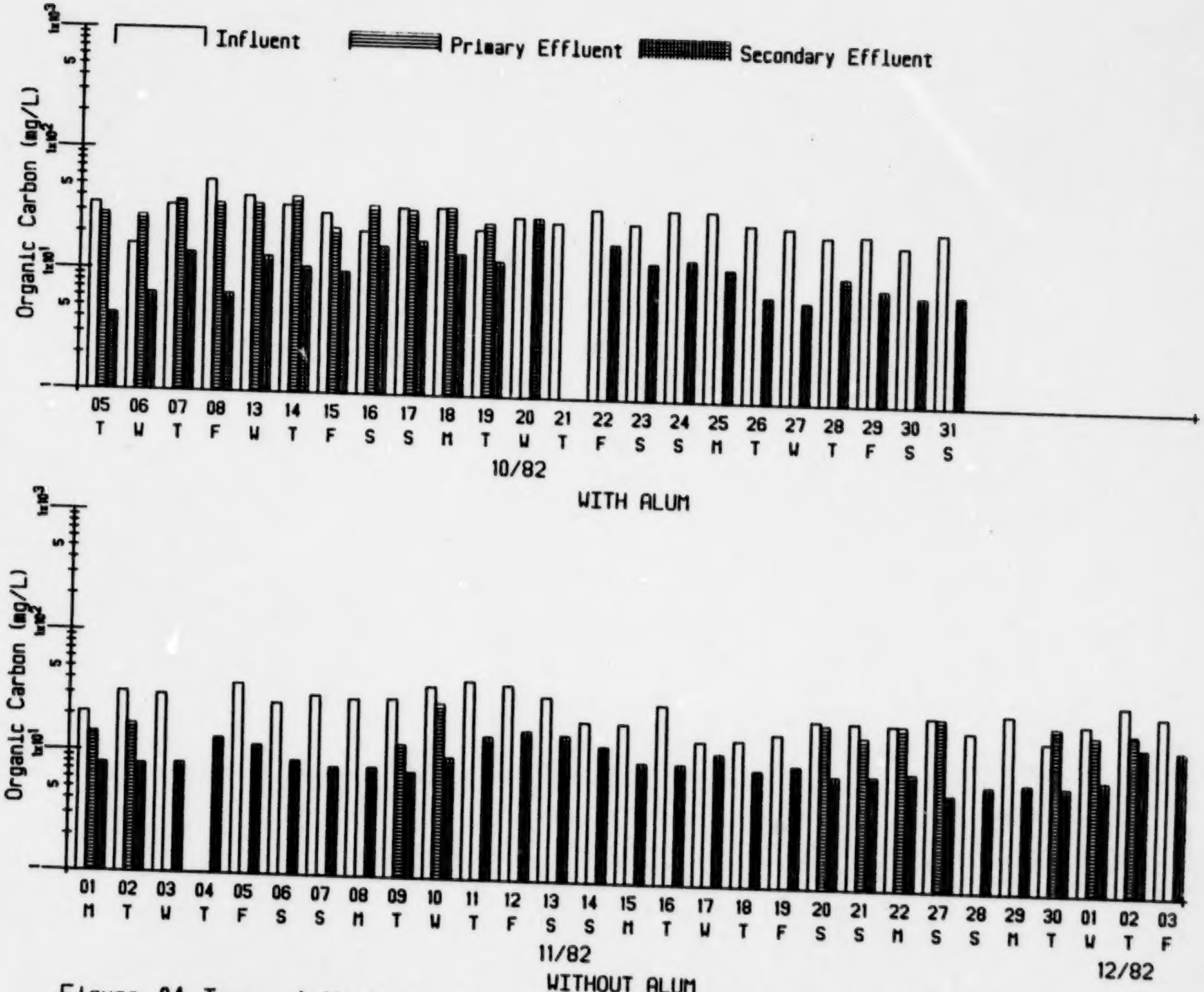
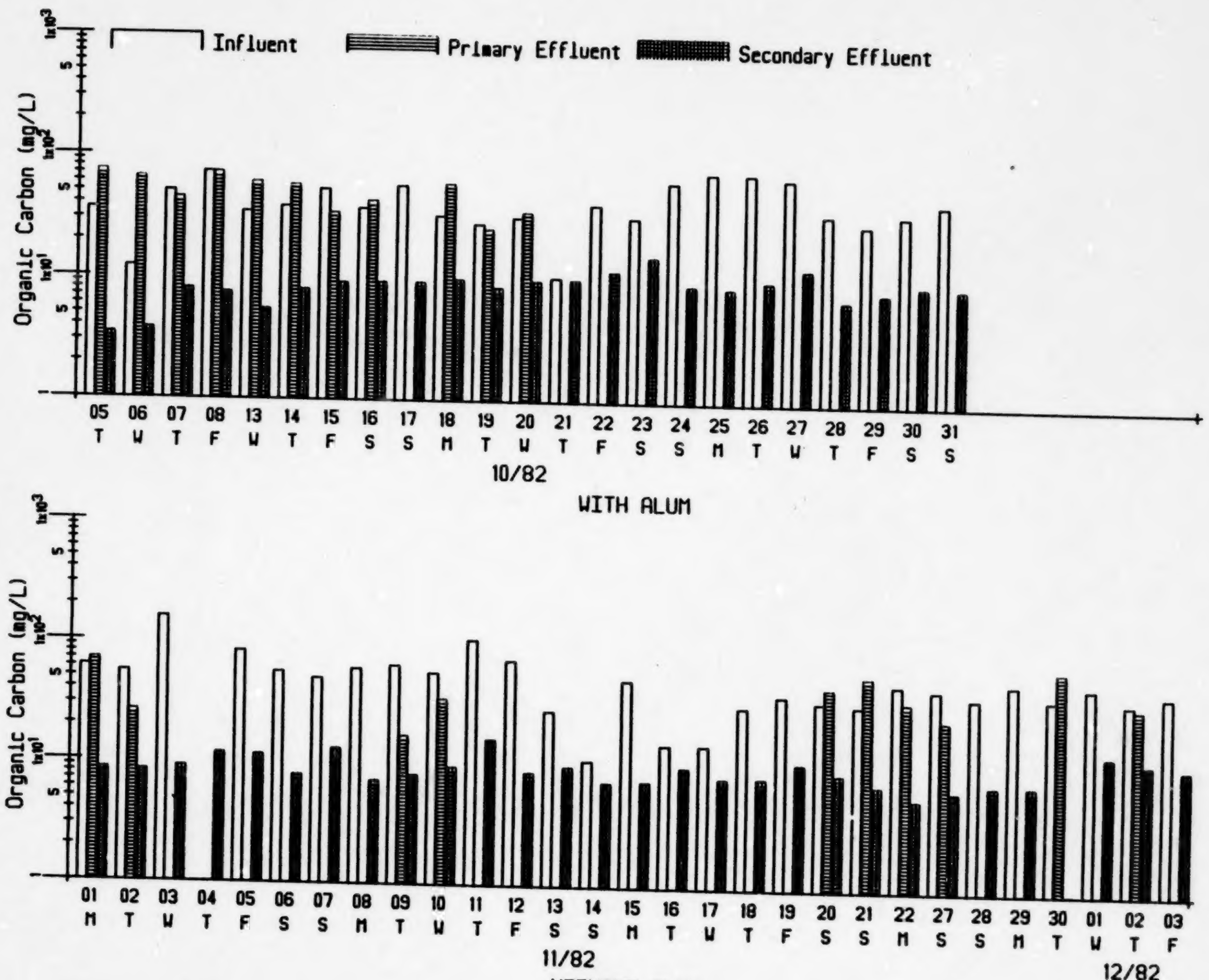


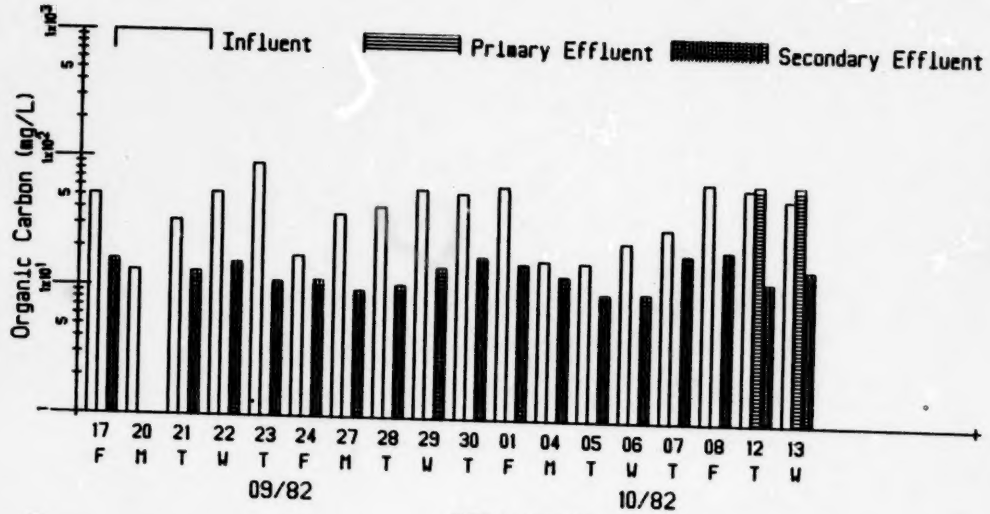
Figure 84 Temporal Variation of Soluble Organic Carbon at Fitchburg (MA) POTW



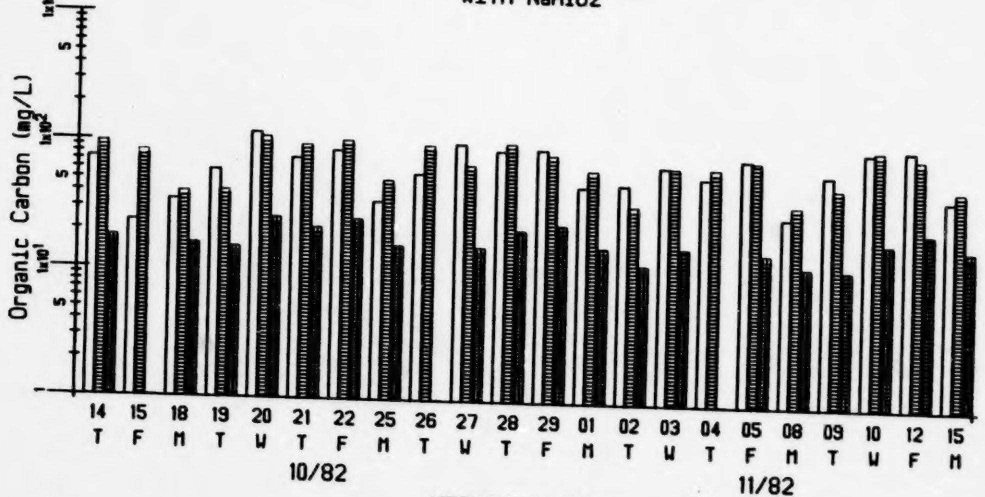
WITH ALUM

WITHOUT ALUM

Figure 85 Temporal Variation of Total Organic Carbon at Fitchburg (MA) POTW

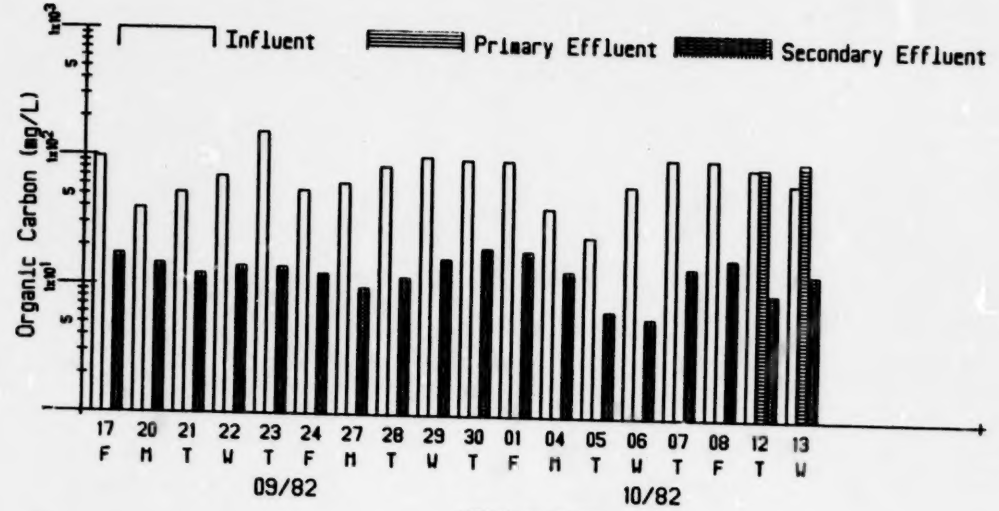


WITH NaAl02

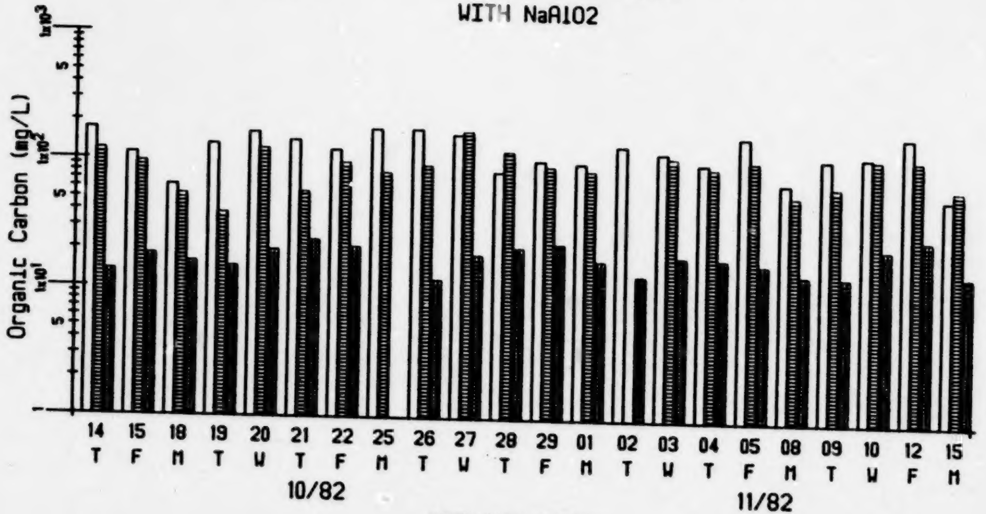


WITHOUT NaAl02

Figure 86 Temporal Variation of Soluble Organic Carbon at Pittsfield (MA) POTW

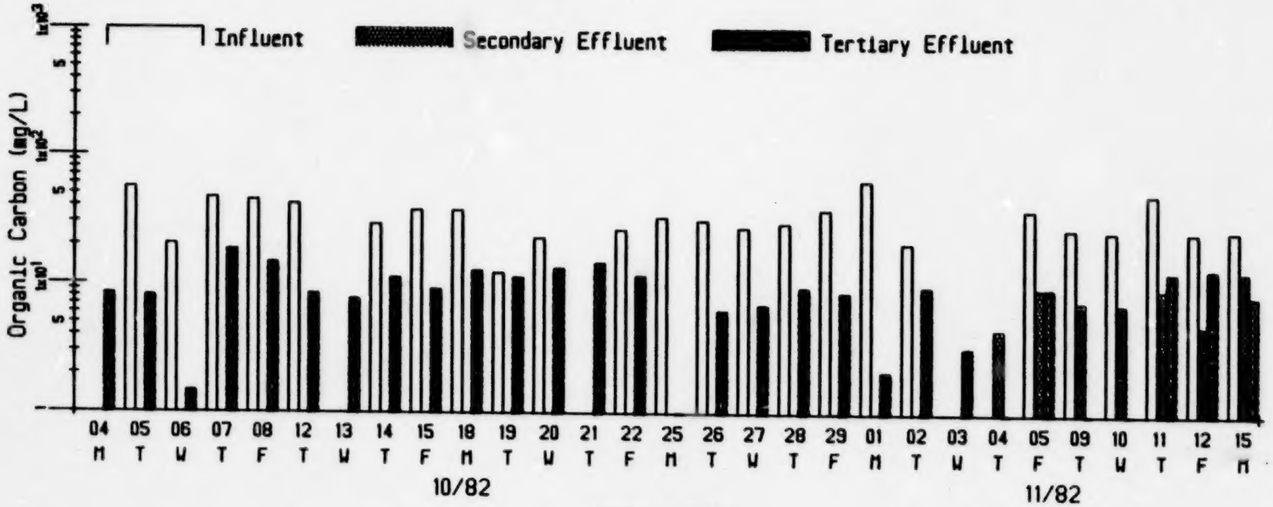


WITH NaAlO2

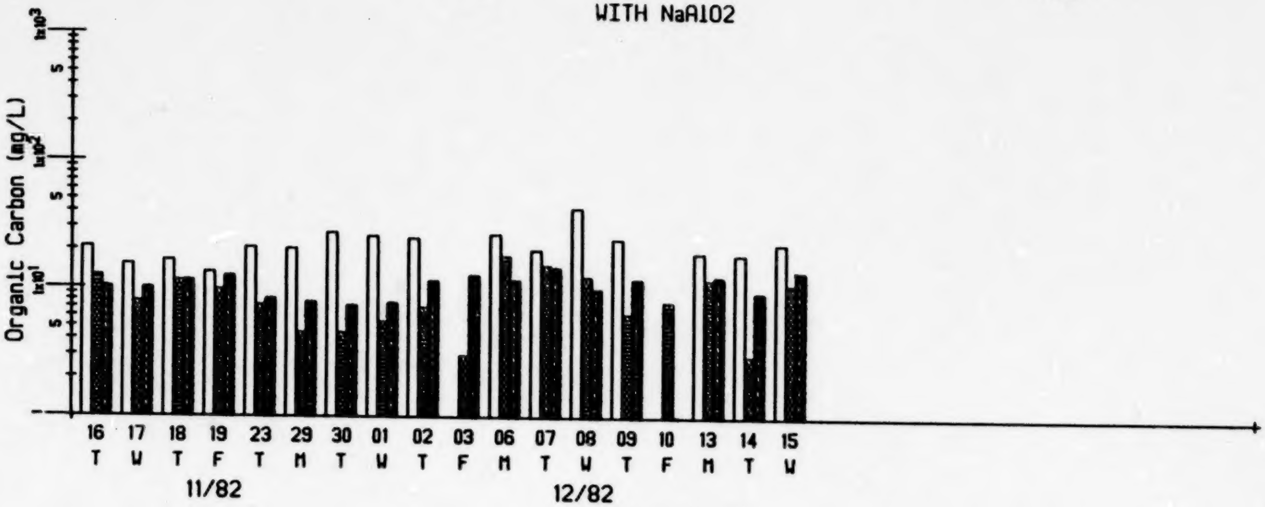


WITHOUT NaAlO2

Figure 87 Temporal Variation of Total Organic Carbon at Pittsfield (MA) POTW



WITH NaAl02



WITHOUT NaAl02

Figure 88 Temporal Variation of Soluble Organic Carbon at Medfield (MA) POTW

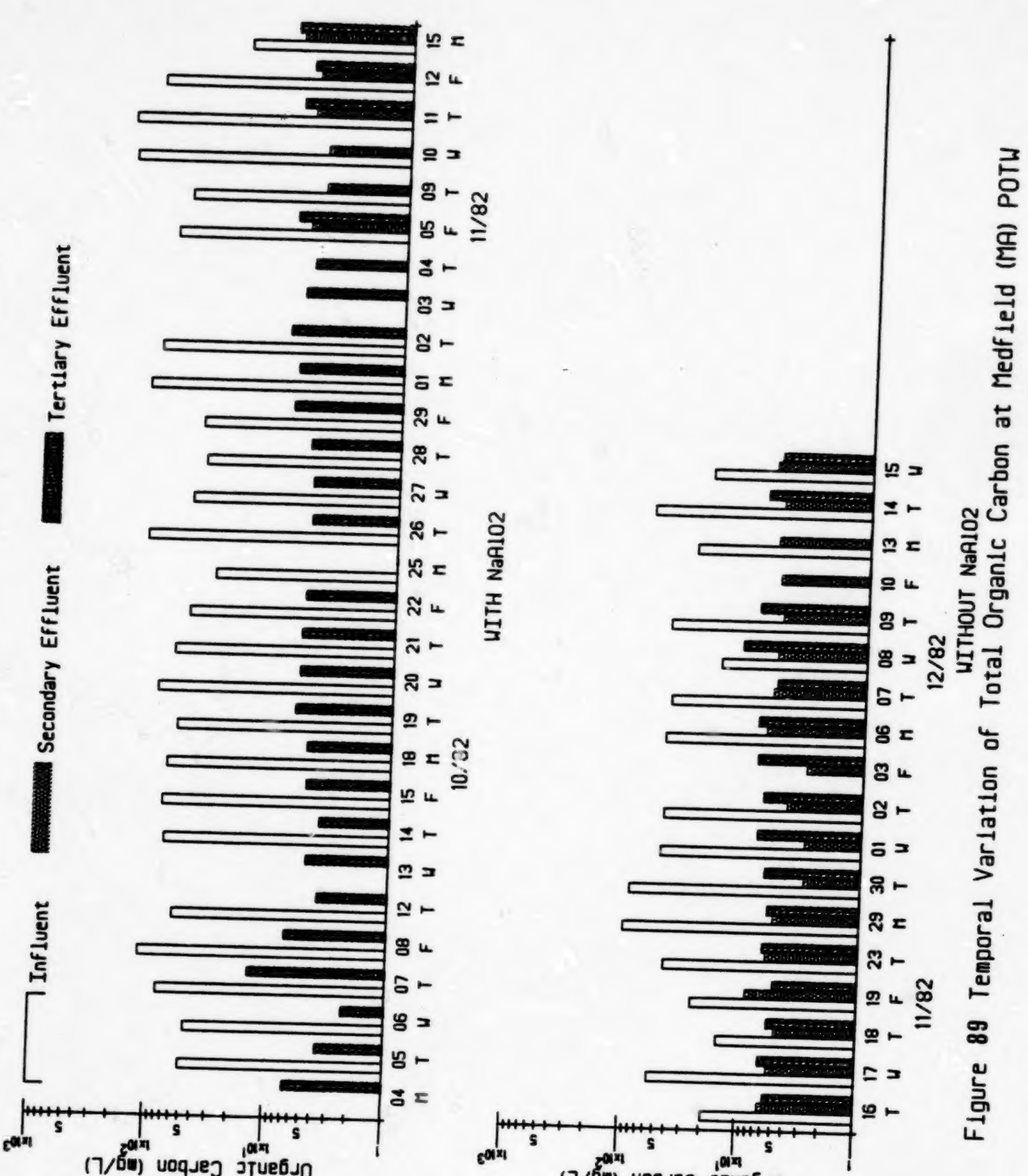


Figure 89 Temporal Variation of Total Organic Carbon at Medfield (MA) POTW

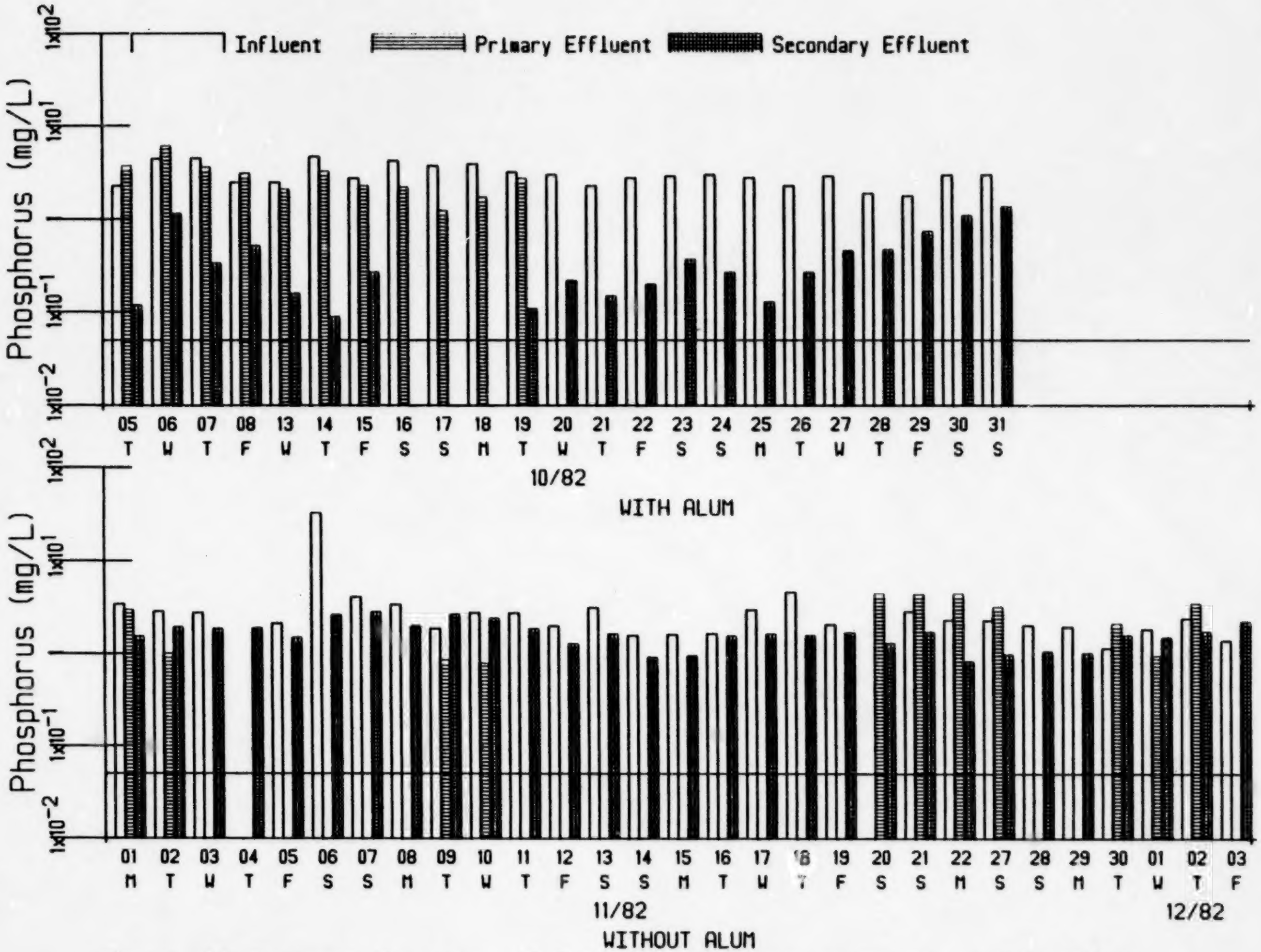


Figure **90** Temporal Variation of Soluble Phosphorus at Fitchburg (MA) POTW

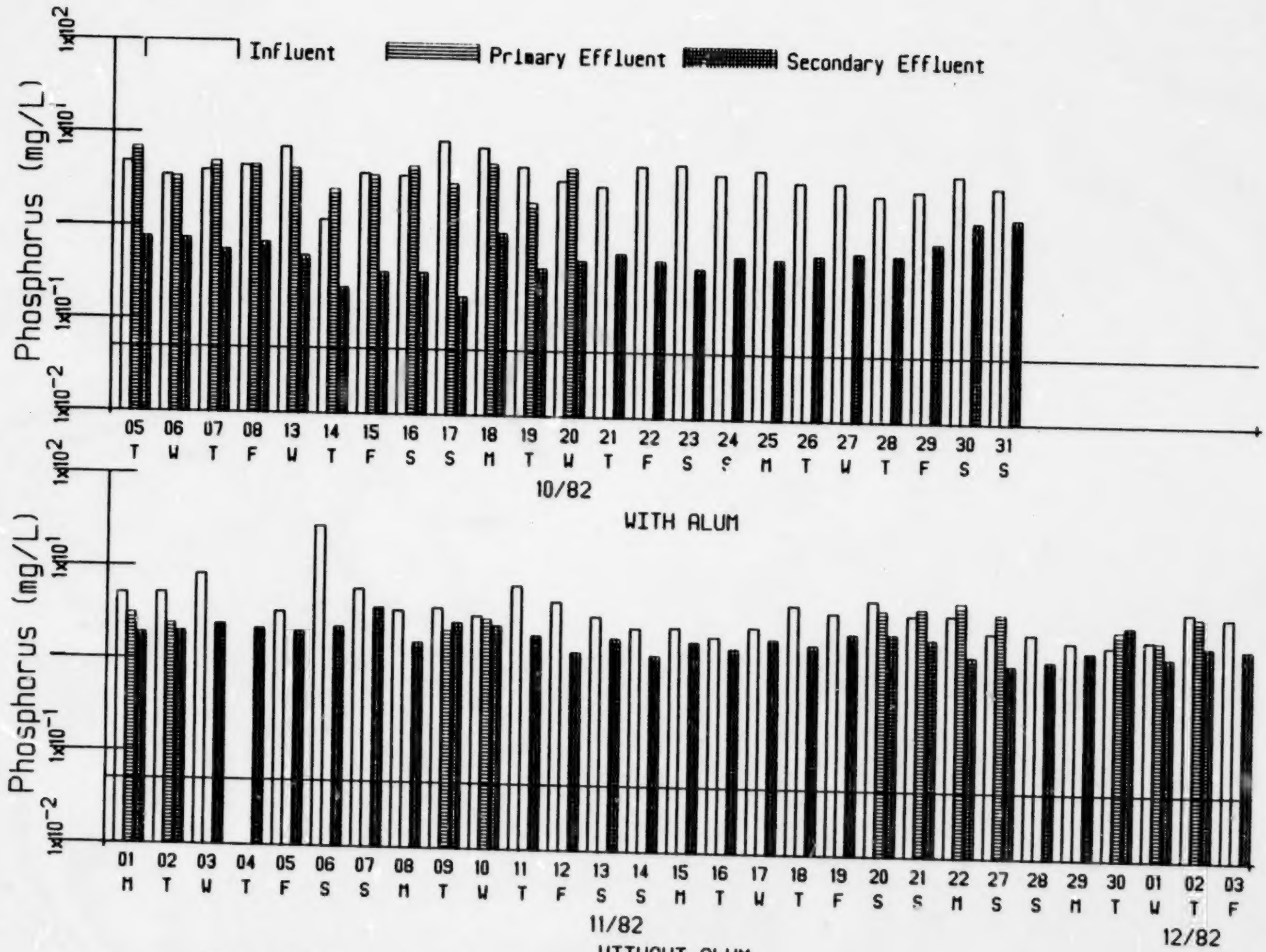


Figure 91 Temporal Variation of Total Phosphorus at Fitchburg (MA) POTW

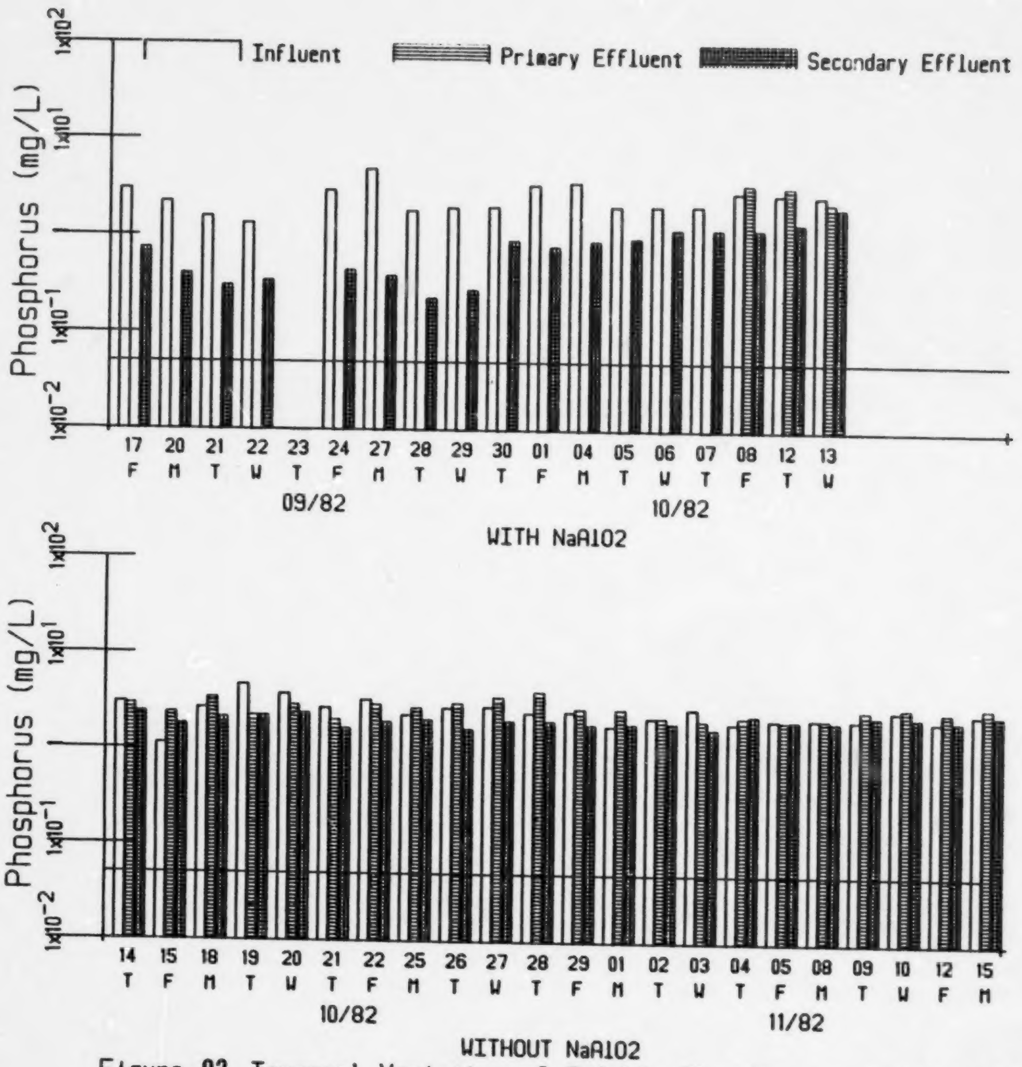
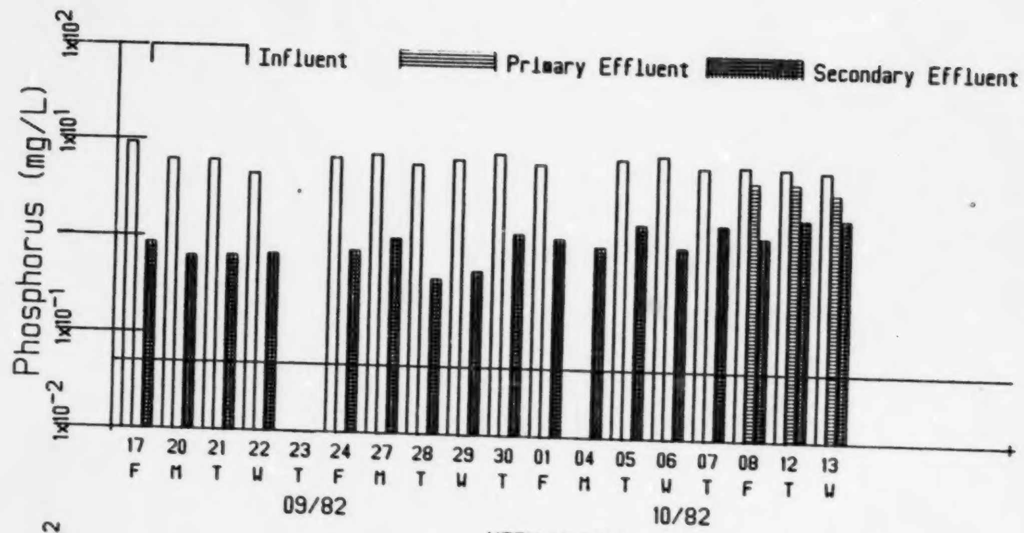
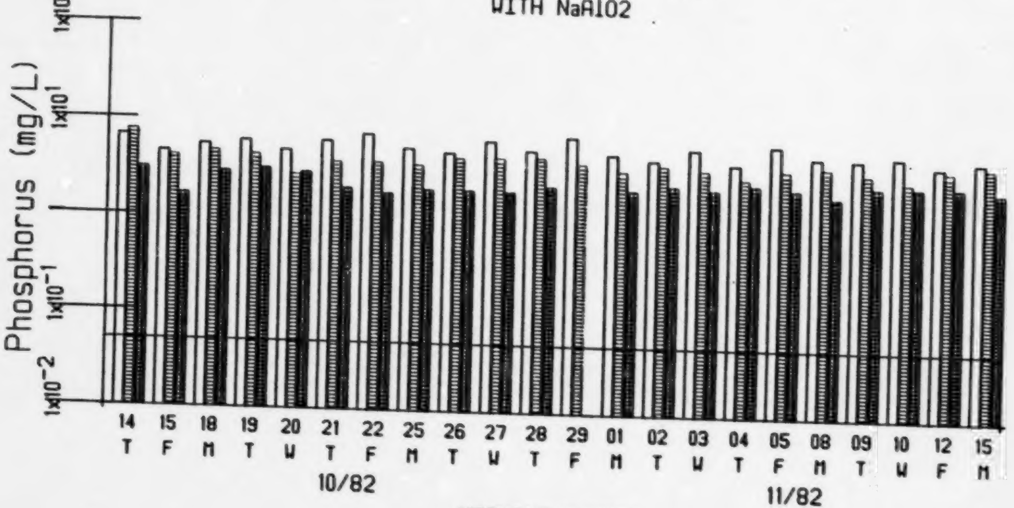


Figure 92 Temporal Variation of Soluble Phosphorus at Pittsfield (MA) POTW



WITH NaAlO2



WITHOUT NaAlO2

Figure 93 Temporal Variation of Total Phosphorus at Pittsfield (MA) POTW

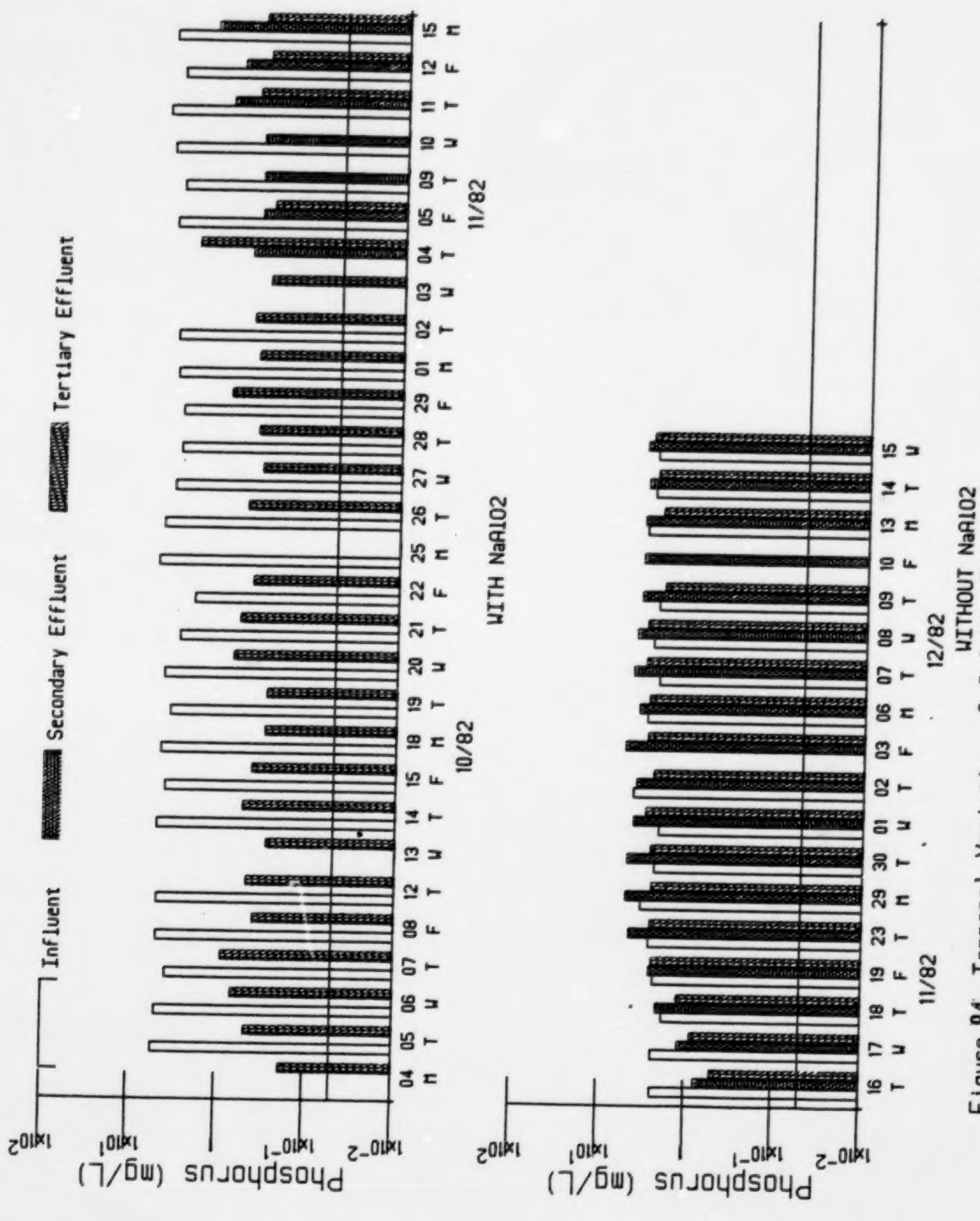


Figure 94 Temporal Variation of Soluble Phosphorus at Medfield (MA) POTW

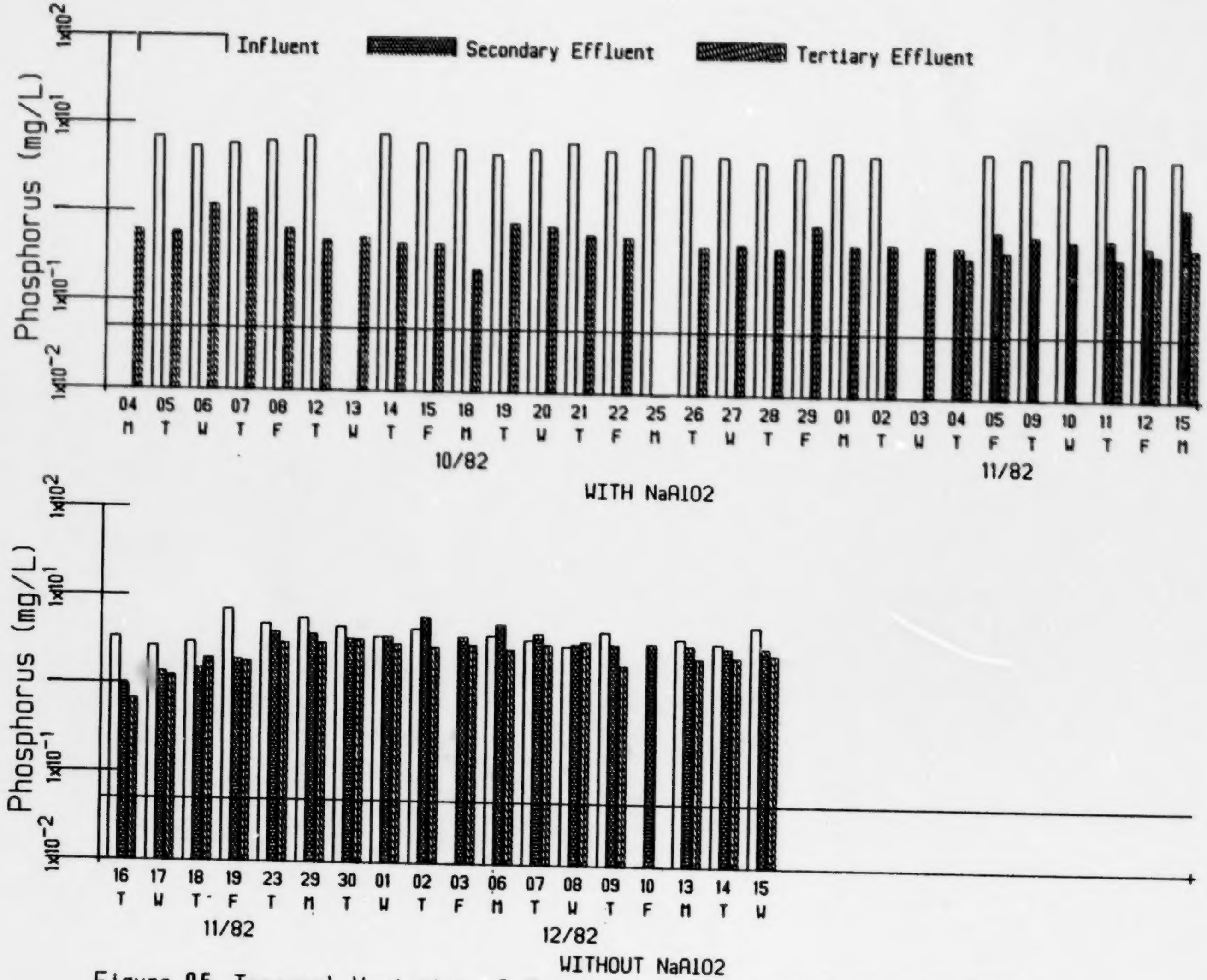


Figure **95** Temporal Variation of Total Phosphorus at Medfield (MA) POTW

APPENDIX B : Descriptive Statistics of Concentrations and Removals

STATISTICAL DESCRIPTION OF SILVER CONCENTRATIONS (ug/L)

WITH ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	24	2.00	109.92	28.79	24.64	12	2.00	41.58	19.51	14.21	24	2.00	2.00	2.00	--
MED	U	26	2.00	65.97	11.04	14.51	8	2.00	2.00	2.00	--	26	2.00	2.00	2.00	--
PIT	U	18	2.00	31.85	20.86	9.37	3	2.00	12.33	8.30	5.53	18	2.00	2.00	2.00	--
FIT	F	24	2.00	23.95	8.17	8.53	11	2.00	11.92	4.56	4.39	22	2.00	2.00	2.00	--
MED	F	27	2.00	21.55	3.20	4.41	8	2.00	2.00	2.00	--	25	2.00	2.00	2.00	--
PIT	F	18	2.00	15.49	5.75	4.99	3	2.00	2.00	2.00	--	18	2.00	2.00	2.00	--

WITHOUT ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	27	2.00	63.98	23.42	17.06	7	2.00	46.10	19.11	15.72	28	2.00	14.98	2.46	2.45
MED	U	14	2.00	28.08	7.67	8.30	17	2.00	2.00	2.00	--	16	2.00	2.00	2.00	--
PIT	U	21	2.00	89.00	31.97	18.10	21	2.00	29.45	14.47	9.74	22	2.00	14.58	2.57	2.68
FIT	F	27	2.00	17.95	3.29	3.86	7	2.00	2.00	2.00	--	28	2.00	2.00	2.00	--
MED	F	14	2.00	12.17	2.73	2.72	17	2.00	2.00	2.00	--	16	2.00	2.00	2.00	--
PIT	F	22	2.00	18.20	4.67	5.50	22	2.00	11.71	2.44	2.07	22	2.00	2.00	2.00	--

STATISTICAL DESCRIPTION OF ARSENIC CONCENTRATIONS (ug/L)

WITH ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	24	5.00	13.60	7.05	2.67	12	5.00	11.53	7.72	2.30	24	5.00	9.41	5.73	1.29
MED	U	26	5.00	14.47	7.70	2.90	8	5.00	7.09	5.64	0.95	26	5.00	14.82	5.99	2.49
PIT	U	17	7.95	31.09	21.49	7.05	3	5.97	8.19	7.08	1.11	17	5.00	9.58	7.39	1.71
FIT	F	23	5.00	11.27	5.73	1.47	11	5.00	5.00	5.00	--	22	5.00	6.83	5.24	0.57
MED	F	26	5.00	11.27	5.79	1.67	8	5.00	5.00	5.00	--	26	5.00	7.19	5.14	0.46
PIT	F	18	5.00	6.77	5.10	0.42	3	5.00	5.00	5.00	--	18	5.00	8.41	5.47	0.95

WITHOUT ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	27	5.00	16.63	7.58	2.78	7	5.00	15.91	7.14	4.05	28	5.00	16.99	7.51	4.50
MED	U	14	5.00	8.51	6.15	1.20	17	5.00	9.58	5.62	1.34	16	5.00	21.94	6.21	4.22
PIT	U	20	7.08	29.19	15.28	5.86	22	5.00	15.98	8.70	2.94	22	5.00	20.24	7.91	4.88
FIT	F	27	5.00	12.65	6.51	2.21	7	5.00	6.43	5.66	0.73	28	5.00	11.14	5.63	1.45
MED	F	14	5.00	8.12	5.84	1.19	16	5.00	7.54	5.29	0.70	16	5.00	6.77	5.15	0.46
PIT	F	22	5.00	17.25	9.06	3.53	22	5.00	8.89	5.51	1.04	22	5.00	6.83	5.24	0.56

STATISTICAL DESCRIPTION OF CADMIUM CONCENTRATIONS (ug/L)

WITH ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	24	0.50	15.84	5.86	3.20	12	0.50	7.52	3.84	2.20	24	0.50	1.71	0.57	0.25
MED	U	26	2.19	17.82	7.70	4.05	8	1.16	9.00	3.49	2.83	26	0.50	2.88	0.80	0.66
PIT	U	17	8.31	40.29	17.29	8.40	3	4.03	21.43	12.92	8.71	17	1.38	5.51	4.10	1.16
FIT	F	23	0.50	8.15	2.05	2.11	12	0.84	14.35	4.61	4.28	21	0.80	4.58	2.09	0.85
MED	F	23	0.50	10.75	2.39	2.58	7	1.14	11.71	4.04	4.10	26	0.50	8.19	2.07	1.66
PIT	F	18	0.50	12.94	5.51	3.87	3	1.97	13.70	9.49	6.53	18	1.47	6.14	4.34	1.29

WITHOUT ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	27	0.50	71.40	7.56	13.16	7	1.11	16.61	4.23	5.49	26	0.50	6.94	0.92	1.37
MED	U	14	0.50	10.57	4.23	3.23	17	0.50	40.11	5.33	9.13	15	0.50	0.50	0.50	--
PIT	U	21	7.22	89.93	23.59	22.08	22	2.41	16.03	8.39	4.14	22	0.50	16.33	4.23	3.41
FIT	F	27	0.50	8.40	1.60	1.72	10	0.90	2.83	1.89	0.65	28	0.50	11.61	2.04	2.30
MED	F	14	0.50	3.71	1.44	1.10	14	0.95	4.21	1.87	0.86	15	0.90	2.96	1.64	0.51
PIT	F	22	0.60	14.74	4.75	3.94	21	1.25	12.40	5.40	3.43	22	1.65	12.87	4.04	2.37

STATISTICAL DESCRIPTION OF CHROMIUM CONCENTRATIONS (ug/L)

WITH ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	24	14.9	346.7	158.8	103.2	12	20.1	208.5	106.6	62.4	24	4.8	36.2	17.3	6.9
MED	U	26	3.6	78.6	25.5	17.9	8	3.0	3.0	3.0	--	25	3.0	6.5	3.3	0.8
PIT	U	18	28.5	75.0	48.1	14.2	3	18.0	129.8	60.4	60.6	18	3.0	10.5	3.8	1.8
FIT	F	23	3.0	78.7	12.0	18.7	11	3.3	60.6	24.5	19.7	22	3.0	3.5	3.0	0.1
MED	F	26	3.0	13.0	3.6	2.0	7	3.0	3.0	3.0	--	27	3.0	3.0	3.0	--
PIT	F	18	3.0	34.1	8.9	8.4	3	3.0	13.1	6.6	5.6	18	3.0	4.2	3.1	0.3

WITHOUT ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	27	8.1	518.3	182.4	141.7	7	31.4	436.2	203.3	120.5	28	3.9	53.7	18.6	11.6
MED	U	14	3.2	49.6	18.8	13.5	17	3.0	13.9	5.0	3.9	16	3.0	30.8	5.2	7.1
PIT	U	21	22.9	112.1	58.4	21.8	22	7.4	69.9	25.8	14.9	22	3.0	17.0	7.0	3.6
FIT	F	27	3.0	35.9	7.3	8.3	7	3.0	45.1	13.6	16.8	28	3.0	5.6	3.2	0.7
MED	F	14	3.0	6.5	3.3	0.9	17	3.0	3.0	3.0	--	16	3.0	3.0	3.0	--
PIT	F	22	3.0	33.8	10.4	9.4	22	3.0	27.8	10.1	8.4	22	3.0	7.1	4.0	1.4

STATISTICAL DESCRIPTION OF COPPER CONCENTRATIONS (ug/L)

WITH ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	24	279.0	877.9	528.9	142.1	12	60.2	828.4	337.6	184.1	24	10.0	97.2	42.3	20.1
MED	U	26	101.0	1790.8	418.3	366.3	8	10.6	47.8	29.3	15.3	26	7.1	37.1	19.1	9.7
PIT	U	17	196.5	697.1	536.1	133.6	3	168.0	265.0	232.7	56.0	17	29.7	82.9	57.9	13.8
FIT	F	24	106.2	193.1	154.5	26.0	12	22.3	203.5	154.4	47.9	23	10.0	75.5	20.5	15.8
MED	F	26	10.0	147.0	55.0	35.7	8	10.0	45.0	16.9	11.7	26	10.0	29.9	13.5	5.0
PIT	F	18	10.0	190.1	105.1	45.6	3	98.0	142.3	122.0	22.4	18	10.0	98.4	52.5	22.6

WITHOUT ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	27	166.7	1175.1	391.8	220.7	7	110.0	490.5	272.5	114.1	28	28.3	290.9	65.5	51.9
MED	U	14	46.9	255.9	157.5	56.2	17	10.0	25.4	12.2	4.5	16	10.0	61.6	17.1	15.6
PIT	U	21	343.5	1322.9	603.8	212.0	21	77.5	452.5	283.2	87.5	22	46.9	179.4	102.4	28.5
FIT	F	27	13.8	180.7	125.5	51.8	7	10.0	290.9	108.8	90.7	27	10.0	56.3	22.2	13.5
MED	F	13	12.1	58.8	29.1	15.4	17	10.0	34.3	13.7	7.3	16	10.0	37.1	12.8	7.4
PIT	F	22	52.3	223.5	145.5	41.5	21	10.0	208.0	147.0	50.1	22	10.0	163.9	73.8	35.7

STATISTICAL DESCRIPTION OF MERCURY CONCENTRATIONS (ug/L)

WITH ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	24	0.20	0.51	0.29	0.07	13	0.20	0.65	0.29	0.12	24	0.20	0.25	0.20	0.01
MED	U	26	0.20	3.24	1.03	0.78	8	0.20	0.23	0.20	0.01	26	0.20	0.26	0.20	0.02
PIT	U	16	0.26	1.04	0.64	0.24	2	0.20	0.26	0.23	0.04	17	0.20	0.65	0.23	0.11
FIT	F	23	0.20	0.34	0.22	0.03	10	0.20	0.26	0.21	0.02	23	0.20	0.26	0.20	0.01
MED	F	23	0.20	0.31	0.22	0.03	8	0.20	0.26	0.21	0.02	26	0.20	0.77	0.23	0.12
PIT	F	14	0.20	1.04	0.31	0.23	2	0.20	0.26	0.23	0.04	17	0.20	0.91	0.30	0.19

WITHOUT ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	27	0.20	0.70	0.34	0.14	10	0.20	0.62	0.30	0.14	27	0.20	0.34	0.22	0.05
MED	U	16	0.68	4.16	1.55	0.87	16	0.20	0.25	0.21	0.02	15	0.20	0.20	0.20	--
PIT	U	22	0.25	1.10	0.52	0.23	21	0.20	0.34	0.22	0.04	22	0.20	0.63	0.23	0.10
FIT	F	26	0.20	0.26	0.21	0.02	10	0.20	0.23	0.20	0.01	28	0.20	0.25	0.20	0.01
MED	F	12	0.20	0.51	0.23	0.09	17	0.20	0.20	0.20	--	15	0.20	0.25	0.20	0.01
PIT	F	22	0.20	0.51	0.23	0.07	21	0.20	0.25	0.20	0.01	22	0.20	0.34	0.21	0.03

STATISTICAL DESCRIPTION OF LEAD CONCENTRATIONS (ug/L)

WITH ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	24	49.6	1778.7	767.3	557.0	12	183.4	1166.9	611.2	338.1	24	15.4	191.7	78.2	42.6
MED	U	26	15.8	266.9	85.1	60.5	8	5.0	17.0	9.2	4.4	25	5.0	27.0	9.0	7.0
PIT	U	17	26.1	143.9	72.3	26.5	3	5.0	24.3	11.4	11.1	17	5.0	10.8	5.9	2.0
FIT	F	23	5.0	123.8	56.2	36.5	11	5.0	72.7	40.2	27.2	22	5.0	81.7	30.2	23.1
MED	F	26	5.0	23.5	7.6	5.4	8	5.0	5.0	5.0	--	25	5.0	18.7	6.4	3.7
PIT	F	18	5.0	64.8	15.2	17.4	3	9.5	31.2	18.0	11.6	18	5.0	5.0	5.0	--

WITHOUT ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	27	41.9	2861.9	872.1	656.3	7	6.6	1841.4	671.3	608.2	28	41.5	568.6	150.0	143.0
MED	U	14	18.0	214.8	62.9	47.8	17	5.0	33.9	12.0	10.1	16	5.0	35.8	9.3	9.0
PIT	U	21	26.9	342.1	108.5	66.5	22	5.0	38.8	17.4	9.1	22	5.0	156.1	28.3	40.3
FIT	F	27	5.0	67.9	28.5	21.0	7	5.0	186.7	40.2	66.1	28	5.0	54.8	15.2	13.3
MED	F	14	5.0	15.4	8.7	4.1	17	5.0	10.9	5.6	1.5	16	5.0	22.1	10.4	5.7
PIT	F	22	5.0	15.3	7.0	3.3	20	5.0	17.4	5.6	2.8	21	5.0	12.7	6.5	2.6

STATISTICAL DESCRIPTION OF ANTIMONY CONCENTRATIONS (ug/L)

WITH ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	24	10.00	21.93	12.66	2.94	12	10.00	15.78	12.51	2.21	24	10.00	18.07	11.58	2.25
MED	U	26	10.00	20.11	14.06	3.07	8	10.00	14.60	12.85	2.00	26	10.00	18.07	12.39	2.49
PIT	U	17	11.99	30.99	20.03	5.13	3	11.95	19.72	16.59	4.10	17	10.00	14.15	11.45	1.27
FIT	F	23	10.00	18.18	11.31	2.22	12	13.16	16.72	14.20	1.19	21	10.00	17.15	11.11	1.74
MED	F	24	10.81	22.49	15.94	3.02	7	12.38	23.92	16.85	3.89	25	10.00	18.59	11.83	2.46
PIT	F	18	10.00	27.80	18.05	4.46	3	19.09	25.03	21.86	2.99	18	10.25	18.49	14.62	2.33

WITHOUT ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	27	10.00	29.89	15.19	4.65	7	10.00	15.87	11.82	2.18	28	10.00	19.37	12.36	2.99
MED	U	14	10.00	18.06	13.45	2.55	17	10.00	14.08	11.07	1.16	16	10.00	19.37	12.73	2.92
PIT	U	21	11.08	27.20	18.58	3.98	22	10.00	19.42	13.17	2.96	22	10.00	29.49	13.05	4.62
FIT	F	27	10.00	40.66	14.72	6.07	8	13.61	19.78	15.64	2.16	28	10.00	26.83	12.36	3.69
MED	F	14	10.09	25.86	18.39	4.64	14	13.61	24.71	16.34	3.18	15	10.00	17.99	12.91	2.83
PIT	F	22	10.00	23.89	14.90	4.12	22	14.85	28.25	21.07	3.77	21	10.00	24.41	13.47	3.91

STATISTICAL DESCRIPTION OF SELENIUM CONCENTRATIONS (ug/L)

WITH ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	24	10.00	22.70	12.19	3.52	12	10.00	15.41	10.45	1.56	24	10.00	17.42	10.83	2.28
MED	U	26	10.00	27.87	13.53	5.27	8	10.00	21.01	13.15	4.27	25	10.00	27.20	12.11	4.68
PIT	U	17	10.00	39.63	25.06	9.42	3	10.00	14.32	11.44	2.49	17	10.00	32.09	16.81	9.07
FIT	F	23	10.00	10.06	10.01	0.02	11	10.00	10.00	10.00	--	22	10.00	10.00	10.00	--
MED	F	26	10.00	10.60	10.02	0.12	7	10.00	10.00	10.00	--	26	10.00	10.00	10.00	--
PIT	F	18	10.00	19.08	10.84	2.35	3	10.00	10.00	10.00	--	18	10.00	13.30	10.28	0.82

WITHOUT ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	27	10.00	20.06	10.75	2.14	7	10.00	18.16	11.17	3.08	28	10.00	14.18	10.16	0.79
MED	U	14	10.00	15.41	10.46	1.45	17	10.00	18.71	11.00	2.26	16	10.00	10.00	10.00	--
PIT	U	20	10.00	27.97	16.04	6.21	22	10.00	23.30	11.63	3.17	22	10.00	17.56	10.65	1.85
FIT	F	27	10.00	10.00	10.00	--	7	10.00	10.00	10.00	--	28	10.00	10.00	10.00	--
MED	F	14	10.00	10.00	10.00	--	16	10.00	10.00	10.00	--	15	10.00	10.75	10.05	0.19
PIT	F	22	10.00	11.63	10.08	0.35	22	10.00	10.00	10.00	--	22	10.00	10.00	10.00	--

STATISTICAL DESCRIPTION OF ZINC CONCENTRATIONS (mg/L)

WITH ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	24	0.30	1.92	0.55	0.39	12	0.30	2.11	0.54	0.51	24	0.30	0.30	0.30	--
MED	U	26	0.30	2.42	0.97	0.71	8	0.30	0.30	0.30	--	26	0.30	0.30	0.30	--
PIT	U	17	0.34	1.74	0.99	0.36	3	0.30	0.61	0.40	0.18	17	0.30	0.30	0.30	--
FIT	F	23	0.30	0.30	0.30	--	12	0.30	0.30	0.30	--	21	0.30	0.30	0.30	--
MED	F	23	0.30	0.30	0.30	--	7	0.30	0.30	0.30	--	26	0.30	0.30	0.30	--
PIT	F	18	0.30	0.30	0.30	--	3	0.30	0.30	0.30	--	18	0.30	0.30	0.30	--

WITHOUT ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	27	0.30	5.48	0.58	1.00	7	0.30	0.42	0.33	0.05	28	0.30	0.30	0.30	--
MED	U	15	0.30	2.92	0.49	0.68	17	0.30	0.30	0.30	--	16	0.30	0.30	0.30	--
PIT	U	21	0.30	2.50	0.79	0.52	21	0.30	1.04	0.49	0.21	22	0.30	0.30	0.30	--
FIT	F	27	0.30	0.30	0.30	--	10	0.30	0.30	0.30	--	28	0.30	0.30	0.30	--
MED	F	14	0.30	0.30	0.30	--	14	0.30	0.30	0.30	--	15	0.30	0.30	0.30	--
PIT	F	22	0.30	0.30	0.30	--	21	0.30	0.30	0.30	--	22	0.30	0.30	0.30	--

STATISTICAL DESCRIPTION OF ALUMINUM CONCENTRATIONS (ug/L)

WITH ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	24	661.9	3541.4	1823.7	759.4	12	524.0	6076.3	1883.8	1619.0	24	420.5	959.7	652.8	152.5
MED	U	26	530.9	5914.5	1889.8	1175.7	8	149.1	1303.9	475.0	392.3	26	20.0	180.3	97.4	39.6
PIT	U	17	12987.	45325.	23367.	8423.2	3	1858.4	3271.4	2339.5	807.2	17	520.2	1843.1	1032.1	269.0
FIT	F	23	92.9	385.5	220.4	87.7	11	120.2	281.2	178.7	43.7	20	30.8	304.8	89.6	54.5
MED	F	23	72.0	403.0	156.6	72.5	7	133.1	353.2	189.5	82.4	26	40.1	350.0	86.4	58.3
PIT	F	18	233.2	714.6	423.0	129.0	3	231.2	425.6	335.3	97.9	18	105.2	291.9	160.1	58.1

WITHOUT ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	27	317.4	5945.4	2006.4	1362.4	7	372.8	2280.3	1382.8	703.3	28	214.1	941.2	533.8	235.9
MED	U	15	981.6	12080.	2546.0	2727.7	17	78.7	291.1	148.9	55.3	16	29.0	134.2	73.3	30.1
PIT	U	21	2666.4	33098.	13352.	6942.7	22	478.0	3075.0	1658.1	703.7	22	382.8	1592.6	1024.9	393.6
FIT	F	26	51.2	198.7	126.2	39.5	7	123.2	223.7	180.3	33.1	28	20.0	232.6	93.3	49.8
MED	F	14	42.4	204.6	100.3	44.8	14	40.0	196.9	115.8	46.6	15	26.7	150.6	68.8	30.8
PIT	F	21	104.0	758.3	317.2	166.1	22	160.6	566.8	319.9	99.3	22	57.1	320.1	117.8	60.3

STATISTICAL DESCRIPTION OF TOC CONCENTRATIONS (mg/L)

WITH ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	24	10.33	76.13	44.09	18.56	12	25.55	74.56	53.68	16.57	24	3.44	15.60	8.88	2.54
MED	U	26	19.45	199.58	80.71	45.19	8	4.86	8.26	6.13	1.07	26	2.30	14.36	6.44	2.32
PIT	U	18	25.31	155.23	78.30	31.15	2	90.95	101.71	96.33	7.61	18	5.97	20.36	13.64	3.97
FIT	F	24	16.17	55.25	30.61	8.25	12	14.33	41.56	31.42	7.53	23	4.31	30.45	12.11	5.69
MED	F	25	12.17	64.01	33.37	12.13	8	4.52	12.95	8.58	3.13	26	1.48	18.56	9.73	3.91
PIT	F	18	13.28	91.37	44.96	22.42	2	72.38	72.38	72.38	--	17	9.71	21.95	14.24	3.68

WITHOUT ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	27	10.87	156.89	51.01	29.35	9	16.86	67.99	38.45	16.35	27	5.71	16.03	9.36	2.43
MED	U	15	15.16	100.39	46.97	24.75	17	3.00	8.74	5.33	1.44	15	5.16	11.18	6.95	1.49
PIT	U	22	57.43	177.62	126.19	37.97	21	38.60	173.13	93.95	30.61	21	11.90	27.48	18.14	4.16
FIT	F	27	15.42	43.50	27.84	7.56	10	12.55	28.25	21.46	4.70	28	6.30	17.30	10.52	3.23
MED	F	15	13.30	42.59	22.50	6.93	17	3.00	18.02	8.63	4.24	16	7.31	14.62	10.81	2.25
PIT	F	22	23.57	117.66	67.80	26.42	22	34.64	109.52	73.78	24.58	19	11.78	25.70	18.06	4.40

STATISTICAL DESCRIPTION OF PHOSPHORUS CONCENTRATIONS (mg/L)

WITH ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	24	1.21	8.60	4.33	1.60	13	1.99	6.99	4.09	1.31	24	0.19	1.93	0.68	0.42
MED	U	26	3.36	7.95	5.58	1.07	8	0.49	1.47	0.77	0.32	27	0.24	1.23	0.59	0.21
PIT	U	16	4.61	9.22	6.95	1.11	3	3.71	4.71	4.38	0.58	17	0.41	2.03	1.09	0.50
FIT	F	24	1.76	4.61	3.03	0.79	12	1.24	6.10	2.94	1.25	21	0.09	1.57	0.48	0.44
MED	F	26	2.00	5.31	3.94	0.89	8	0.42	1.47	0.71	0.36	27	0.19	2.12	0.54	0.36
PIT	F	17	1.34	4.82	2.53	0.86	3	2.29	3.52	3.04	0.66	17	0.23	2.04	0.81	0.49

WITHOUT ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	27	1.91	28.26	4.74	4.95	10	2.24	5.48	3.56	1.14	28	1.18	3.85	2.03	0.59
MED	U	15	2.66	7.10	4.18	1.19	17	1.38	6.07	3.39	1.17	16	1.25	3.38	2.59	0.62
PIT	U	22	4.21	7.45	5.55	0.96	22	2.78	7.64	4.07	0.96	21	1.70	3.19	2.41	0.42
FIT	F	26	1.14	32.56	3.57	5.97	10	0.80	4.52	2.61	1.62	28	0.84	2.85	1.69	0.55
MED	F	15	1.85	4.25	2.70	0.60	17	1.21	5.31	3.76	1.05	16	0.88	3.21	2.52	0.65
PIT	F	22	1.13	4.70	2.56	0.72	22	2.07	4.11	2.75	0.53	22	1.67	2.50	2.09	0.25

STATISTICAL DESCRIPTION OF FRACTIONAL SILVER REMOVAL

WITH ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	10	0.020	0.847	0.392	0.285	9	0.234	0.927	0.598	0.235	20	0.814	0.982	0.920	0.043
MED	U	5	0.822	0.970	0.905	0.054	0					9	0.817	0.970	0.882	0.056
PIT	U	2	0.613	0.627	0.620	0.010	2	0.303	0.324	0.313	0.015	16	0.806	0.937	0.903	0.041
FIT	F	6	0.392	0.908	0.663	0.234	2	0.401	0.506	0.454	0.075	8	0.830	0.916	0.884	0.031
MED	F	2	0.864	0.907	0.886	0.030	0					1	0.864	0.864	0.864	--
PIT	F	1	0.802	0.802	0.802	--	0					7	0.802	0.871	0.824	0.028

WITHOUT ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	6	-4.240	0.939	-0.529	1.892	5	0.517	4.240	1.480	1.562	20	0.467	0.969	0.901	0.107
MED	U	6	0.805	0.929	0.845	0.057	0					6	0.805	0.929	0.845	0.057
PIT	U	19	-0.068	0.944	0.584	0.268	15	-0.838	0.996	0.380	0.397	20	0.029	0.978	0.883	0.204
FIT	F	2	0.823	0.889	0.856	0.046	0					3	0.823	0.889	0.846	0.037
MED	F	1	0.836	0.836	0.836	--	0					1	0.836	0.836	0.836	--
PIT	F	6	-4.855	0.890	-0.125	2.319	1	4.855	4.855	4.855	--	5	0.613	0.890	0.820	0.117

STATISTICAL DESCRIPTION OF FRACTIONAL ARSENIC REMOVAL

WITH ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	11	-1.306	0.476	-0.328	0.590	10	-0.214	1.306	0.476	0.474	20	-0.882	0.633	0.107	0.386
MED	U	6	-0.418	0.654	0.353	0.396	2	-0.744	0.418	-0.163	0.821	16	-0.448	0.654	0.206	0.374
PIT	U	3	0.418	0.607	0.542	0.107	3	-0.139	0.220	-0.013	0.201	16	0.358	0.825	0.641	0.131
FIT	F	3	0.261	0.261	0.261	--	3	-0.366	-0.134	-0.257	0.117	10	-0.366	0.556	0.087	0.279
MED	F	4	0.076	0.466	0.267	0.221	1	-0.136	-0.136	-0.136	--	9	-0.438	0.556	0.134	0.336
PIT	F	1	0.261	0.261	0.261	--	0					6	-0.682	0.261	-0.239	0.314

WITHOUT ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	7	-0.323	0.412	0.144	0.268	5	-0.016	0.907	0.285	0.397	22	-1.829	0.584	-0.017	0.683
MED	U	8	-0.102	0.322	0.215	0.142	5	-3.388	0.421	-0.667	1.549	10	-3.388	0.412	-0.162	1.155
PIT	U	20	0.088	0.717	0.398	0.182	19	-1.134	0.441	0.016	0.455	20	-1.046	0.817	0.414	0.500
FIT	F	6	-0.286	0.605	0.081	0.304	5	-0.354	0.286	0.015	0.310	20	-0.790	0.605	0.082	0.369
MED	F	8	-0.286	0.384	0.151	0.232	5	-0.354	0.286	-0.017	0.240	8	-0.354	0.384	0.140	0.260
PIT	F	18	-0.643	0.710	0.374	0.293	9	-0.366	0.719	0.069	0.312	19	-0.366	0.710	0.387	0.258

STATISTICAL DESCRIPTION OF FRACTIONAL CADMIUM REMOVAL

WITH ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	12	-0.580	0.821	0.260	0.445	11	0.159	1.475	0.668	0.403	23	0.679	0.968	0.887	0.064
MED	U	7	-0.243	0.895	0.593	0.392	5	0.060	1.147	0.421	0.426	23	-0.132	0.972	0.838	0.255
PIT	U	3	-0.317	0.707	0.053	0.568	3	0.193	1.072	0.779	0.507	17	0.469	0.908	0.730	0.115
FIT	F	12	-7.969	0.744	-0.975	2.349	10	-0.779	6.106	0.757	2.045	20	-2.960	0.849	-0.835	1.140
MED	F	6	-1.388	-0.129	-0.564	0.475	4	0.493	1.182	0.870	0.361	21	-3.600	0.904	-0.269	1.065
PIT	F	3	-4.524	0.563	-1.934	2.545	3	0.111	3.605	1.821	1.748	18	-4.220	0.674	-0.404	1.280

WITHOUT ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	7	-5.540	0.720	-0.905	2.245	6	0.215	5.540	1.799	2.085	23	-0.164	0.993	0.815	0.246
MED	U	14	-24.43	0.846	-2.143	6.556	12	0.194	4.729	1.272	1.455	11	0.643	0.953	0.862	0.092
PIT	U	21	0.011	0.832	0.537	0.237	21	-0.446	0.627	0.213	0.232	21	0.064	0.981	0.750	0.213
FIT	F	10	-4.660	0.398	-1.327	1.688	10	-1.735	3.220	0.408	1.642	27	-12.55	0.940	-0.939	2.502
MED	F	13	-1.800	0.642	-0.612	0.740	12	-1.805	1.353	-0.164	1.006	13	-2.760	0.664	-0.863	1.319
PIT	F	21	-2.523	0.565	-0.561	1.045	21	-5.157	2.757	-0.052	1.572	22	-7.094	0.818	-0.569	1.782

STATISTICAL DESCRIPTION OF FRACTIONAL CHROMIUM REMOVAL

WITH ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	12	-11.09	0.901	-1.319	3.678	12	0.075	10.947	2.009	3.326	24	-0.140	0.978	0.758	0.295
MED	U	7	0.169	0.954	0.777	0.277	0					22	0.169	0.954	0.777	0.277
PIT	U	3	-0.896	0.477	-0.142	0.696	3	0.436	1.823	1.054	0.706	18	0.754	0.960	0.916	0.045
FIT	F	11	-11.87	-0.093	-3.762	4.663	9	0.093	11.805	4.608	4.905	13	-0.067	0.962	0.546	0.329
MED	F	1	0.178	0.178	0.178	--	0					5	0.178	0.769	0.401	0.226
PIT	F	2	-1.209	0.101	-0.554	0.926	2	0.180	1.703	0.942	1.077	13	-0.100	0.912	0.567	0.273

WITHOUT ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	7	-2.035	0.696	-0.617	0.938	7	0.246	2.424	1.389	0.773	27	-5.631	0.985	0.581	1.260
MED	U	14	-0.075	0.940	0.575	0.323	4	-0.661	0.432	0.028	0.487	14	-0.205	0.940	0.583	0.390
PIT	U	21	0.305	0.770	0.595	0.136	21	-0.045	0.598	0.275	0.151	21	0.619	0.949	0.871	0.078
FIT	F	5	-0.469	0.509	-0.093	0.370	4	0.552	1.110	0.853	0.287	12	0.178	0.877	0.589	0.251
MED	F	2	0.099	0.539	0.319	0.311	0					2	0.099	0.539	0.319	0.311
PIT	F	15	-3.357	0.708	-0.206	0.993	16	-0.790	3.887	0.652	1.017	17	-0.790	0.897	0.432	0.437

STATISTICAL DESCRIPTION OF FRACTIONAL COPPER REMOVAL

WITH ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	12	-0.790	0.901	0.256	0.409	12	0.037	1.769	0.664	0.413	24	0.837	0.986	0.915	0.041
MED	U	7	0.902	0.977	0.946	0.029	5	-0.127	0.067	-0.005	0.072	23	0.775	0.987	0.925	0.060
PIT	U	3	0.497	0.653	0.579	0.078	3	0.205	0.413	0.300	0.105	17	0.721	0.939	0.884	0.049
FIT	F	11	-0.587	0.798	-0.093	0.371	10	0.111	1.289	0.913	0.370	23	0.538	0.948	0.869	0.095
MED	F	7	0.154	0.876	0.630	0.257	4	-0.146	0.156	0.028	0.130	22	0.071	0.932	0.653	0.217
PIT	F	3	-0.671	-0.207	-0.485	0.245	3	0.599	1.415	0.902	0.447	18	-1.359	0.839	0.319	0.618

WITHOUT ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	7	-0.521	0.512	0.015	0.446	7	0.059	1.286	0.574	0.459	27	-0.382	0.970	0.762	0.271
MED	U	14	0.774	0.961	0.916	0.052	6	-0.367	0.077	-0.115	0.165	14	0.562	0.957	0.866	0.122
PIT	U	20	0.292	0.845	0.498	0.158	20	-0.014	0.507	0.318	0.129	21	0.665	0.942	0.815	0.070
FIT	F	7	-6.557	0.797	-2.135	3.186	6	-0.275	6.830	2.089	2.842	26	0.010	0.942	0.749	0.261
MED	F	13	0.176	0.830	0.508	0.223	5	-1.161	0.450	-0.152	0.616	13	-0.984	0.830	0.450	0.481
PIT	F	21	-2.640	0.924	-0.131	0.680	21	-0.416	2.248	0.561	0.550	22	-0.392	0.942	0.430	0.343

STATISTICAL DESCRIPTION OF FRACTIONAL MERCURY REMOVAL

WITH ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	9	-1.500	0.333	-0.008	0.584	11	0.097	1.731	0.361	0.463	20	0.167	0.608	0.327	0.118
MED	U	7	0.623	0.938	0.820	0.126	1	0.014	0.014	0.014	--	21	0.200	0.938	0.704	0.200
PIT	U	2	0.188	0.231	0.209	0.031	2	-0.192	0.188	-0.002	0.269	16	-0.250	0.808	0.556	0.306
FIT	F	4	-0.300	0.412	0.128	0.302	1	-0.300	-0.300	-0.300	--	7	-0.300	0.412	0.159	0.217
MED	F	1	0.355	0.355	0.355	--	0					6	-1.962	0.355	-0.135	0.897
PIT	F	1	-0.300	-0.300	-0.300	--	1	0.300	0.300	0.300	--	6	-1.250	0.333	-0.271	0.666

WITHOUT ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	8	-1.000	0.623	0.059	0.540	6	-0.560	1.355	0.224	0.692	18	-0.700	0.714	0.374	0.363
MED	U	15	0.706	0.952	0.835	0.069	3	0.025	0.049	0.039	0.013	15	0.706	0.952	0.844	0.066
PIT	U	20	0.200	0.791	0.535	0.157	9	-0.915	0.206	-0.059	0.363	22	-0.340	0.818	0.486	0.273
FIT	F	2	-0.150	0.200	0.025	0.247	1	0.150	0.150	0.150	--	3	0.200	0.231	0.210	0.018
MED	F	2	0.200	0.608	0.404	0.288	1	-0.098	-0.098	-0.098	--	2	0.200	0.510	0.355	0.219
PIT	F	7	-0.250	0.608	0.244	0.269	1	-0.700	-0.700	-0.700	--	8	-0.700	0.608	0.126	0.416

STATISTICAL DESCRIPTION OF FRACTIONAL LEAD REMOVAL

WITH ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	12	-2.374	0.827	-0.211	0.981	12	0.127	2.525	0.992	0.706	24	-0.531	0.984	0.686	0.385
MED	U	7	0.708	0.975	0.864	0.104	4	0.000	0.070	0.048	0.033	22	0.503	0.968	0.837	0.124
PIT	U	3	0.831	0.917	0.865	0.046	1	0.094	0.094	0.094	--	17	0.809	0.946	0.909	0.043
FIT	F	11	-0.043	0.854	0.362	0.260	9	-1.493	0.963	0.139	0.752	20	-9.060	0.928	-0.398	2.382
MED	F	3	0.040	0.246	0.109	0.119	1	-0.077	-0.077	-0.077	--	10	-2.744	0.739	-0.126	0.972
PIT	F	3	-2.696	0.683	-1.232	1.734	3	0.149	3.103	1.646	1.477	11	0.136	0.923	0.551	0.317

WITHOUT ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	7	-1.742	0.991	-0.293	1.067	7	-0.134	1.584	0.665	0.679	27	-9.662	0.963	0.257	2.055
MED	U	14	-0.082	0.925	0.741	0.268	11	-0.660	0.904	0.083	0.404	14	0.233	0.977	0.806	0.194
PIT	U	21	0.623	0.948	0.826	0.085	18	-1.617	0.270	0.127	0.458	20	-0.837	0.985	0.753	0.420
FIT	F	7	-7.806	0.848	-1.288	3.264	7	-0.336	7.390	1.702	2.966	27	-3.494	0.926	0.031	1.250
MED	F	12	-1.092	0.675	0.203	0.549	12	-1.282	1.132	-0.403	0.733	11	-0.949	0.472	-0.219	0.435
PIT	F	9	-2.474	0.674	0.140	1.000	7	-1.134	2.474	-0.330	1.288	11	-1.134	0.603	-0.096	0.719

STATISTICAL DESCRIPTION OF FRACTIONAL ANTIMONY REMOVAL

WITH ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	11	-0.457	0.351	-0.020	0.246	10	-0.036	0.334	0.148	0.134	21	-0.289	0.398	0.070	0.195
MED	U	7	-0.460	0.340	0.094	0.300	5	-0.361	0.460	0.084	0.295	20	-0.284	0.482	0.089	0.225
PIT	U	3	-0.266	0.243	0.019	0.260	3	-0.077	0.481	0.266	0.300	17	0.058	0.662	0.390	0.174
FIT	F	12	-0.496	0.146	-0.275	0.168	10	0.138	0.533	0.324	0.126	15	-0.715	0.450	-0.018	0.279
MED	F	6	-0.623	0.116	-0.176	0.286	4	0.222	0.748	0.485	0.236	21	-0.363	0.555	0.239	0.216
PIT	F	3	-0.909	-0.483	-0.743	0.228	3	0.295	0.713	0.539	0.217	18	-0.614	0.483	0.145	0.260

WITHOUT ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	7	-0.190	0.418	0.133	0.252	5	-0.668	0.417	-0.045	0.428	27	-0.621	0.651	0.130	0.286
MED	U	14	-0.380	0.419	0.146	0.221	12	-0.919	0.144	-0.157	0.325	14	-0.899	0.410	0.011	0.414
PIT	U	21	-0.154	0.632	0.262	0.213	19	-0.419	0.416	0.068	0.225	21	-0.078	0.618	0.323	0.157
FIT	F	8	-0.380	0.282	0.001	0.211	8	-0.108	0.516	0.302	0.206	25	-1.683	0.754	0.063	0.479
MED	F	13	-1.164	0.474	0.034	0.426	12	-0.161	1.288	0.241	0.358	13	-0.228	0.575	0.258	0.250
PIT	F	22	-1.392	0.201	-0.495	0.399	21	-0.498	1.161	0.549	0.388	20	-0.586	0.581	0.035	0.357

STATISTICAL DESCRIPTION OF FRACTIONAL SELENIUM REMOVAL

WITH ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	10	-0.541	0.464	0.189	0.292	4	-0.742	-0.100	-0.306	0.311	14	-0.742	0.559	0.098	0.388
MED	U	6	-1.101	0.533	-0.271	0.618	4	-0.639	1.101	0.379	0.783	11	-1.231	0.641	0.035	0.631
PIT	U	3	0.333	0.562	0.441	0.115	1	0.173	0.173	0.173	--	17	-2.209	0.747	0.183	0.709
FIT	F	0					0					2	0.006	0.006	0.006	--
MED	F	0					0					1	0.057	0.057	0.057	--
PIT	F	0					1	-0.045	-0.045	-0.045	--	5	-0.255	0.408	0.098	0.272

WITHOUT ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	3	-0.816	0.097	-0.241	0.501	2	0.004	0.816	0.410	0.574	7	-0.418	0.502	0.121	0.289
MED	U	6	-0.871	0.351	-0.163	0.420	4	0.004	0.871	0.356	0.366	2	0.097	0.351	0.224	0.179
PIT	U	14	-0.221	0.642	0.272	0.294	9	-0.303	0.586	0.135	0.256	13	0.041	0.642	0.386	0.190
FIT	F	0					0					0				
MED	F	0					1	-0.750	-0.750	-0.750	--	1	-0.750	-0.750	-0.750	--
PIT	F	2	0.006	0.140	0.073	0.095	0					2	0.006	0.140	0.073	0.095

STATISTICAL DESCRIPTION OF FRACTIONAL ZINC REMOVAL

WITH ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	9	-3.489	0.738	-0.357	1.333	6	0.060	3.851	1.054	1.427	16	0.118	0.844	0.449	0.203
MED	U	7	0.118	0.872	0.559	0.318	0					20	0.118	0.876	0.553	0.284
PIT	U	3	0.016	0.750	0.295	0.398	1	0.500	0.500	0.500	--	17	0.118	0.828	0.647	0.167
FIT	F	0					0					0				
MED	F	0					0					0				
PIT	F	0					0					0				

WITHOUT ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	3	-0.400	-0.029	-0.199	0.187	3	0.147	0.400	0.238	0.141	9	0.118	0.945	0.469	0.297
MED	U	2	0.464	0.897	0.681	0.306	0					2	0.464	0.897	0.681	0.306
PIT	U	20	-2.467	0.792	0.072	0.837	14	0.075	2.467	0.594	0.690	18	0.143	0.880	0.571	0.181
FIT	F	0					0					0				
MED	F	0					0					0				
PIT	F	0					0					0				

STATISTICAL DESCRIPTION OF FRACTIONAL ALUMINUM REMOVAL

WITH ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	12	-1.60	0.72	-0.40	0.74	12	-0.57	2.11	0.62	0.83	24	-0.36	0.84	0.56	0.27
MED	U	7	0.30	0.97	0.76	0.23	5	0.01	0.17	0.09	0.07	23	0.83	0.99	0.93	0.04
PIT	U	3	0.81	0.91	0.86	0.05	3	0.05	0.08	0.06	0.02	17	0.90	0.98	0.95	0.02
FIT	F	11	-0.29	0.49	0.12	0.27	8	0.24	0.63	0.47	0.13	19	-0.73	0.83	0.54	0.35
MED	F	5	-0.30	0.24	0.05	0.21	3	0.52	0.56	0.54	0.02	20	-2.84	0.80	0.31	0.78
PIT	F	3	0.05	0.15	0.11	0.05	3	0.27	0.65	0.49	0.20	18	0.24	0.78	0.60	0.16

WITHOUT ALUM / ALUMINATE

		INFLUENT					PRIMARY EFFLUENT					EFFLUENT				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	7	-0.60	0.85	0.16	0.49	7	-0.51	0.91	0.49	0.54	27	-0.88	0.93	0.60	0.39
MED	U	15	0.85	0.98	0.92	0.04	15	-0.002	0.11	0.04	0.03	15	0.90	0.99	0.96	0.02
PIT	U	21	0.50	0.96	0.84	0.12	21	-0.07	0.29	0.06	0.09	21	0.77	0.98	0.90	0.06
FIT	F	7	-1.06	0.28	-0.43	0.49	7	0.31	1.19	0.60	0.34	26	-1.27	0.87	0.24	0.45
MED	F	13	-1.09	0.66	-0.31	0.55	12	-1.04	1.57	0.54	0.71	13	-1.46	0.66	0.25	0.54
PIT	F	21	-1.73	0.50	-0.23	0.65	21	0.13	1.63	0.75	0.45	21	-0.44	0.92	0.52	0.34

STATISTICAL DESCRIPTION OF FRACTIONAL TOC REMOVAL

WITH ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	12	-4.443	0.353	-0.623	1.278	12	0.473	5.133	1.413	1.253	24	0.032	0.905	0.752	0.178
MED	U	7	0.631	0.975	0.863	0.147	5	-0.043	0.032	-0.010	0.027	23	0.588	0.960	0.892	0.088
PIT	U	2	-0.478	-0.017	-0.248	0.326	2	0.911	1.280	1.095	0.261	18	0.625	0.909	0.806	0.075
FIT	F	12	-0.720	0.354	-0.045	0.344	12	0.304	1.327	0.656	0.273	22	0.237	0.883	0.616	0.143
MED	F	7	0.406	0.816	0.679	0.156	4	-0.331	0.165	-0.031	0.223	22	0.071	0.967	0.663	0.192
PIT	F	2	-0.286	-0.079	-0.183	0.146	2	0.891	1.001	0.946	0.078	17	0.229	0.877	0.630	0.183

WITHOUT ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	9	-0.752	0.738	0.074	0.546	8	0.138	1.531	0.639	0.449	26	0.335	0.942	0.760	0.158
MED	U	15	0.659	0.967	0.838	0.108	14	-0.329	0.140	-0.038	0.100	14	0.339	0.941	0.803	0.156
PIT	U	21	-0.459	0.710	0.208	0.269	20	0.179	1.201	0.646	0.232	21	0.743	0.933	0.840	0.057
FIT	F	9	-0.352	0.580	0.206	0.278	10	0.141	0.922	0.480	0.248	27	0.202	0.768	0.608	0.137
MED	F	15	0.240	0.838	0.571	0.221	15	-0.343	0.240	-0.884	0.139	15	0.059	0.766	0.482	0.196
PIT	F	22	-2.529	0.317	-0.198	0.583	19	0.439	1.071	0.770	0.190	19	0.540	0.843	0.721	0.094

STATISTICAL DESCRIPTION OF FRACTIONAL PHOSPHORUS REMOVAL

WITH ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	13	-1.149	0.642	-0.016	0.498	13	0.232	1.959	0.872	0.489	24	0.529	0.978	0.827	0.105
MED	U	7	0.705	0.920	0.834	0.087	5	0.022	0.192	0.077	0.069	23	0.774	0.955	0.888	0.049
PIT	U	3	0.281	0.403	0.328	0.065	3	0.271	0.511	0.398	0.121	16	0.673	0.934	0.839	0.080
FIT	F	12	-0.646	0.662	0.116	0.384	9	0.426	1.594	0.889	0.333	21	0.542	0.980	0.831	0.145
MED	F	7	0.651	0.901	0.797	0.100	5	0.029	0.249	0.118	0.080	23	0.706	0.932	0.863	0.060
PIT	F	3	-0.231	0.133	-0.105	0.206	3	0.095	0.808	0.535	0.385	17	0.227	0.919	0.665	0.199

WITHOUT ALUM / ALUMINATE

		PRIMARY REMOVAL					SECONDARY REMOVAL					OVERALL REMOVAL				
PLANT	TYP	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD	N	MIN	MAX	MEAN	SD
FIT	U	10	-0.628	0.530	-0.459	0.386	10	-0.173	1.171	0.392	0.451	27	-0.681	0.917	0.431	0.286
MED	U	15	-0.370	0.727	-0.159	0.316	15	-0.163	0.736	0.192	0.241	15	-0.142	0.737	0.351	0.212
PIT	U	22	-0.147	0.480	0.255	0.163	21	-0.033	0.680	0.302	0.164	21	0.369	0.752	0.547	0.106
FIT	F	9	-0.965	0.709	-0.106	0.686	9	-0.978	1.600	0.283	0.867	26	-0.630	0.918	0.285	0.340
MED	F	15	-1.042	0.500	-0.388	0.423	15	0.059	0.916	0.442	0.247	15	-0.437	0.636	0.053	0.297
PIT	F	22	-1.142	0.515	-0.143	0.348	22	-0.057	0.855	0.268	0.223	21	-0.628	0.517	0.131	0.260

APPENDIX C : Results of t-tests

RESULTS OF t-TESTS

AG:FIT	$\nu=25$	$\alpha=0.05$	$t_{\alpha/2}=2.060$	$T=0.737$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.708$		Accept H_0
AG:MED	$\nu=11$	$\alpha=0.05$	$t_{\alpha/2}=2.201$	$T=1.240$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.796$		Accept H_0
AG:PIT	$\nu=21$	$\alpha=0.05$	$t_{\alpha/2}=2.080$	$T=0.428$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.721$		Accept H_0
AL:FIT	$\nu=47$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=-0.475$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Accept H_0
AL:MED	$\nu=34$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=-2.521$	Reject H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Reject H_0
AL:PIT	$\nu=27$	$\alpha=0.05$	$t_{\alpha/2}=2.052$	$T=3.326$	Reject H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.703$		Reject H_0
AS:FIT	$\nu=33$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=0.733$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Accept H_0
AS:MED	$\nu=10$	$\alpha=0.05$	$t_{\alpha/2}=2.228$	$T=0.976$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.812$		Accept H_0
AS:PIT	$\nu=22$	$\alpha=0.05$	$t_{\alpha/2}=2.074$	$T=1.948$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.717$		Reject H_0
CD:FIT	$\nu=25$	$\alpha=0.05$	$t_{\alpha/2}=2.060$	$T=1.358$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.708$		Accept H_0
CD:MED	$\nu=31$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=-0.400$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Accept H_0
CD:PIT	$\nu=32$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=-0.369$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Accept H_0
CR:FIT	$\nu=29$	$\alpha=0.05$	$t_{\alpha/2}=2.045$	$T=0.708$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.699$		Accept H_0

RESULTS OF t-TESTS (continued)

CR:MED	$\nu=21$	$\alpha=0.05$	$t_{\alpha/2}=2.080$	$T=1.619$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.721$		Accept H_0
CR:PIT	$\nu=33$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=2.244$	Reject H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Reject H_0
CU:FIT	$\nu=27$	$\alpha=0.05$	$t_{\alpha/2}=2.052$	$T=2.897$	Reject H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.703$		Reject H_0
CU:MED	$\nu=17$	$\alpha=0.05$	$t_{\alpha/2}=2.110$	$T=1.689$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.740$		Accept H_0
CU:PIT	$\nu=35$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=3.565$	Reject H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Reject H_0
HG:FIT	$\nu=20$	$\alpha=0.05$	$t_{\alpha/2}=2.086$	$T=-0.525$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.725$		Accept H_0
HG:MED	$\nu=26$	$\alpha=0.05$	$t_{\alpha/2}=2.056$	$T=-2.988$	Reject H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.706$		Reject H_0
HG:PIT	$\nu=31$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=0.728$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Accept H_0
PB:FIT	$\nu=28$	$\alpha=0.05$	$t_{\alpha/2}=2.048$	$T=1.064$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.701$		Accept H_0
PB:MED	$\nu=20$	$\alpha=0.05$	$t_{\alpha/2}=2.086$	$T=0.533$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.725$		Accept H_0
PB:PIT	$\nu=19$	$\alpha=0.05$	$t_{\alpha/2}=2.093$	$T=1.651$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.729$		Accept H_0
SB:FIT	$\nu=45$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=-0.862$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Accept H_0
SB:MED	$\nu=18$	$\alpha=0.05$	$t_{\alpha/2}=2.101$	$T=0.642$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.734$		Accept H_0

RESULTS OF t-TESTS (continued)

SB:PIT	$\nu=33$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=1.233$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Accept H_0
SE:FIT	$\nu=16$	$\alpha=0.05$	$t_{\alpha/2}=2.120$	$T=-0.153$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.746$		Accept H_0
SE:MED	$\nu=7$	$\alpha=0.05$	$t_{\alpha/2}=2.365$	$T=-0.827$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.895$		Accept H_0
SE:PIT	$\nu=19$	$\alpha=0.05$	$t_{\alpha/2}=2.093$	$T=-1.129$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.729$		Accept H_0
ZN:FIT	$\nu=12$	$\alpha=0.05$	$t_{\alpha/2}=2.179$	$T=-0.180$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.782$		Accept H_0
ZN:MED	$\nu=1$	$\alpha=0.05$	$t_{\alpha/2}=12.706$	$T=-0.568$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=6.314$		Accept H_0
ZN:PIT	$\nu=33$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=1.292$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Accept H_0
P:FIT	$\nu=34$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=6.704$	Reject H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Reject H_0
P:MED	$\nu=15$	$\alpha=0.05$	$t_{\alpha/2}=2.131$	$T=9.662$	Reject H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.753$		Reject H_0
P:PIT	$\nu=35$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=9.549$	Reject H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Reject H_0
TOC:FIT	$\nu=46$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=-0.168$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Accept H_0
TOC:MED	$\nu=18$	$\alpha=0.05$	$t_{\alpha/2}=2.101$	$T=1.954$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.734$		Reject H_0
TOC:PIT	$\nu=31$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=-1.573$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Accept H_0

RESULTS OF t-TESTS (continued)

TSP:FIT	$\nu=27$	$\alpha=0.05$	$t_{\alpha/2}=2.052$	$T=1.724$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.703$		Reject H_0
TSP:MED	$\nu=32$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=0.906$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Accept H_0
TSP:PIT	$\nu=8$	$\alpha=0.05$	$t_{\alpha/2}=2.306$	$T=-1.169$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.860$		Accept H_0
BOD:FIT	$\nu=33$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=3.618$	Reject H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Reject H_0
BOD:MED	$\nu=4$	$\alpha=0.05$	$t_{\alpha/2}=2.776$	$T=-0.171$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=2.132$		Accept H_0
BOD:PIT	$\nu=14$	$\alpha=0.05$	$t_{\alpha/2}=2.145$	$T=0.571$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.761$		Accept H_0
VSS:FIT	$\nu=27$	$\alpha=0.05$	$t_{\alpha/2}=2.052$	$T=1.853$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.703$		Reject H_0
TURB:FIT	$\nu=34$	$\alpha=0.05$	$t_{\alpha/2}=1.960$	$T=1.561$	Accept H_0
		$\alpha=0.10$	$t_{\alpha/2}=1.645$		Accept H_0

APPENDIX D : Field Data

FIELD DATA : FITCHBURG TREATMENT PLANT

S.NO	LOC&TYP	DATE	FLOW	C.pH	TSPF	TSPL	VSS	BODF	BODL	DO	FTP	TURB	MLSS
35	INF U	10 5 82	9.01	6.60	136		100				6.23	120	5045
37	INF U	10 6 82	9.57	6.20	88		60	150			4.67	125	5940
47	INF U	10 7 82	10.02	6.30	187		103	219				119	4715
49	INF U	10 8 82	11.57	6.50	183		150	216				148	5090
59	INF U	10 9 82	13.96	6.10	36		24	187				69	3275
61	INF U	10 10 82	11.30	7.20	29		15	104				23	6235
63	INF U	10 11 82	10.45	6.60	74		56	118				37	6995
65	INF U	10 12 82	10.46	6.50	70		58	107				33	4860
79	INF U	10 13 82	10.46	6.40	60		41	112			3.54	160	2075
81	INF U	10 14 82	11.78	6.30	112		82	175			4.15	145	3965
91	INF U	10 15 82	9.88	6.50	187		120	141				120	4495
93	INF U	10 16 82	8.42	7.20	98		78	234				44	4885
95	INF U	10 17 82	8.19	7.20	200		142	213				58	5745
97	INF U	10 18 82	9.52	7.00	106		100	256				52	4510
107	INF U	10 19 82	9.35	6.50	92		92	131				55	5475
109	INF U	10 20 82	9.53	6.70	92		78	121				170	5870
119	INF U	10 21 82	9.65	6.60	116		96	140				150	5270
121	INF U	10 22 82	10.04	6.50	200		172	276				149	7090
127	INF U	10 23 82	9.03	6.50	64		64	360				142	5890
129	INF U	10 24 82	8.59	6.80	140		108	196				62	6190
131	INF U	10 25 82	8.01	6.40	180		131	201				83	6185
141	INF U	10 26 82	7.74	6.50	110		78	180				155	5505
143	INF U	10 27 82	9.52	6.50	59		37	165				110	5235
153	INF U	10 28 82	8.43	6.40	100		74	190			3.52	115	8460
155	INF U	10 29 82	9.43	7.00	79		57	92			3.17	94	6570
161	INF U	10 30 82	8.18	6.40	320	182	240	246				165	7460
163	INF U	10 31 82	8.85	6.40	109	98	82	182				48	5406
173	INF U	11 1 82	8.24	6.40	248		196	324				140	5725
175	INF U	11 2 82	9.00	6.60	227		160	267				205	8400
177	INF U	11 3 82	8.49	6.70	80		47	246			4.93	115	
187	INF U	11 4 82	9.23										
189	INF U	11 5 82	12.14	6.60	143		90	188	137		5.98	120	4100
195	INF U	11 6 82	9.04	0.00	122		76	142					6240
197	INF U	11 7 82	8.91	5.40	148		100	189				60	5845
199	INF U	11 8 82	9.52	6.40	43		33	87				37	6670

FIELD DATA : FITCHBURG TREATMENT PLANT (continued)

S.NO	LOC&TYP	DATE	FLOW	C.pH	TSPF	TSPL	VSS	BODF	BODL	DO	FTP	TURB	MLSS
209	INF U	11 9 82	8.99	6.70	126		109	93			6.73	115	5330
211	INF U	11 10 82	9.75	6.70	240		100	168				170	5295
221	INF U	11 11 82	10.03	6.60	434		352	206				170	7460
223	INF U	11 12 82	10.05	6.70	172		168	165				120	8950
229	INF U	11 13 82	13.96	6.30	136		108	221				50	5025
231	INF U	11 14 82	10.24	6.70	160		100	95				32	5025
237	INF U	11 15 82	12.17	6.50	77		61	130				67	4390
239	INF U	11 16 82	9.93	6.60	70		50	85				80	4735
245	INF U	11 17 82	10.56	6.50	67		53	96				133	5470
247	INF U	11 18 82	11.07		148		116	64	80			60	4960
253	INF U	11 19 82	10.78	6.50	193		90	136				103	5050
255	INF U	11 20 82	9.97	6.50	175		111	180				149	5005
257	INF U	11 21 82	8.57	6.70	208		154	198				76	5720
259	INF U	11 22 82	11.40	6.50	124		100	127				72	5050
265	INF U	11 27 82	8.93	6.70	144		114	196				73	6025
267	INF U	11 28 82	9.26	6.70	34		26	101				33	5800
269	INF U	11 29 82	11.13	6.70	74		68	104				38	5250
275	INF U	11 30 82	10.17	6.70	87		66	112				38	4995
277	INF U	12 1 82	10.52	6.40	88		60	105					5035
283	INF U	12 2 82	10.85	6.90	133		97	110			5.18	110	5665
285	INF U	12 3 82	10.21	6.90	57		55	81	107		5.83	123	6165
635	EFF U	10 5 82		6.60	7		4	11			0.27	6	
637	EFF U	10 6 82		6.50	7		4	11			0.41	4	
647	EFF U	10 7 82		6.70	17		4	18				10	
649	EFF U	10 8 82		6.70	7		2	9				5	
679	EFF U	10 13 82		6.60	10		5	6			0.38	7	
681	EFF U	10 14 82		6.30	12		1	19			0.38	9	
691	EFF U	10 15 82		6.80	11		6	6				9	
693	EFF U	10 16 82		7.70	23		17	16				8	
695	EFF U	10 17 82		7.00	19		12	15				13	
697	EFF U	10 18 82		6.60	10		10	21		3.0		6	
707	EFF U	10 19 82		6.70	14		12	17				12	
709	EFF U	10 20 82		6.70	8		6	11				10	
719	EFF U	10 21 82		6.70	10		9	11				12	
721	EFF U	10 22 82		6.70	12		9	14				14	

FIELD DATA : FITCHBURG TREATMENT PLANT (continued)

S.NO	LOC&TYP	DATE	FLOW	C.pH	TSPF	TSPL	VSS	BODF	BODL	DO	FTP	TURB	MLSS
727	EFF U	10 23 82		6.80	12		6	22				13	
729	EFF U	10 24 82		6.90	16		14	16				14	
731	EFF U	10 25 82		6.90	21		12	11		2.70		16	
741	EFF U	10 26 82		6.70	15		10	10		2.70		13	
743	EFF U	10 27 82		6.50	7		4	5		2.70		6	
753	EFF U	10 28 82		6.60	7		3	8		2.80	0.60	6	
755	EFF U	10 29 82		6.70	9		4	11		2.70	1.15	7	
761	EFF U	10 30 82		6.60	10	36.5	0	14				7	
763	EFF U	10 31 82		6.60	20	16.6	3	21				14	
773	EFF U	11 1 82		6.50	15		6	32				16	
775	EFF U	11 2 82		6.70	12		6	21		3.10		10	
777	EFF U	11 3 82		6.50	3		3	27		2.90		2	
787	EFF U	11 4 82		6.70	9		6	10		2.40		13	
789	EFF U	11 5 82		6.80	10		5	19	1.8	2.50		9	
795	EFF U	11 6 82			22		12	24					
797	EFF U	11 7 82		6.30	27		5	33		3.90		19	
799	EFF U	11 8 82		6.70	10		2	17				9	
809	EFF U	11 9 82		6.70	7		5	17		2.97		9	
811	EFF U	11 10 82		6.60	8		8	7				10	
821	EFF U	11 11 82		6.60	18		16	9				16	
823	EFF U	11 12 82		7.40	10		10	9		2.30		11	
829	EFF U	11 13 82		6.80	14		10	11				11	
831	EFF U	11 14 82		6.80	28		18	6				5	
837	EFF U	11 15 82		6.70	13		11	9		3.10		14	
839	EFF U	11 16 82		6.80	6		5	6		3.00		7	
845	EFF U	11 17 82		6.60	25		18	16		3.00		16	
847	EFF U	11 18 82			28		28	14	7.6			9	
853	EFF U	11 19 82		7.00	46		20	16				13	
855	EFF U	11 20 82		6.50	42		21	30				14	
857	EFF U	11 21 82		6.70	20		10	19				10	
859	EFF U	11 22 82		7.00	7		6	11		2.40		5	
865	EFF U	11 27 82		6.80	11		7	15		1.90		7	
867	EFF U	11 28 82		6.80	17		13	18		1.80		17	
869	EFF U	11 29 82		6.50	19		17	23		2.70		24	
875	EFF U	11 30 82		6.20	151		114	45				99	
877	EFF U	12 1 82		6.00	24		9	13	2.6				
883	EFF U	12 2 82		6.90	14		10	12			1.33	12	
885	EFF U	12 3 82		6.90	10		10	14	10.6		1.15	8	

FIELD DATA : PITTSFIELD TREATMENT PLANT

S.NO	LOC&TYP	DATE	A.TEMP	FLOW	C.pH	G.TEMP	TSSF	TSSL	VSS	SM	BODF	BODL	DO	CL	FTP	MLSS
1	INF U	9 17 82	10.6	10.087	7.30	10.3	337		249	13.0						3940
3	INF U	9 20 82	4.4	10.656	7.30	8.5				12.0						
5	INF U	9 21 82	11.1	11.677	7.30	9.8				11.0			0.38			
7	INF U	9 22 82	12.2	11.745	7.35	10.0	137		90	11.0	314					3900
9	INF U	9 23 82	12.8	10.961	7.40	10.0				12.5						
11	INF U	9 24 82	12.2	8.780	7.35	10.0	251		183	11.0	279					4300
13	INF U	9 27 82	18.3	8.609	7.40	10.5				12.5						
15	INF U	9 28 82	11.7	9.461	7.60	10.0				11.0						
17	INF U	9 29 82	15.6	8.949	7.60	10.0	285		218	12.5	230					3550
19	INF U	9 30 82	13.3	8.586	7.70	10.0				14.0						
21	INF U	10 1 82	10.6	8.521	7.70		145		93	8.0	201					3810
23	INF U	10 4 82	11.1	8.175	7.45	9.0		173		10.0		83				
27	INF U	10 5 82	5.6	10.261	7.50	10.0				3.2	5		0.38			
29	INF U	10 6 82	6.7	10.267	7.95	10.0				11.5						
39	INF U	10 7 82	6.7	9.438	7.80	10.0	230		179	8.5	282					3800
41	INF U	10 8 82	12.2	8.534	7.95	10.0	233		144	13.0	318					4000
53	INF U	10 12 82	8.3	8.015	7.50	8.5		209		9.0		128				
71	INF U	10 13 82	8.9	9.042	7.40	8.7	222	218	167	13.0	262					3620
73	INF U	10 14 82	7.8	8.973	7.70	9.5		212		10.0		290				
83	INF U	10 15 82	10.0	8.738	7.90	11.2	281	175		12.0	230					3770
85	INF U	10 18 82	1.1	8.398	7.40	9.5		225		9.0						
99	INF U	10 19 82	-0.6	8.519	7.90	10.2		218		12.0			0.53			
101	INF U	10 20 82	1.1	8.566	8.30	11.2	196		150	10.0	364	203				3840
111	INF U	10 21 82	9.4	8.297	7.70	12.5		336		13.0						
113	INF U	10 22 82	1.7	8.108	7.80	12.0	327	220	237	17.0	422					3750
123	INF U	10 25 82	-3.3	8.157	7.55	7.0		368		12.5		203				
133	INF U	10 26 82	7.2	8.313	8.00	8.0		295		12.0						
135	INF U	10 27 82	-2.2	8.301	8.30	8.5	305	301	232	11.5	382	268	1.00			3760
145	INF U	10 28 82	-3.3	8.128	8.20	7.5		193		10.5						
147	INF U	10 29 82	0.0	8.200	7.80	8.4	380	355	258	13.5	415					3840
157	INF U	11 1 82	13.9	8.168	7.40	10.0		195		9.5		154				
165	INF U	11 2 82	10.0	8.140	7.80	10.3	226	229		11.0						3800
167	INF U	11 3 82	16.7	7.701	7.80	13.2	251	214	188	12.0	369	173				
179	INF U	11 4 82	17.8	8.119	7.70	12.5		197		10.0			0.40			
181	INF U	11 5 82	6.7	9.384	7.80	13.0	329	244	229	12.5	379					3420
191	INF U	11 8 82	2.2	8.305	7.30	8.5		155		8.0		255				
201	INF U	11 9 82	5.0	8.438	8.50	10.0		124		11.0			1.60			
203	INF U	11 10 82	-1.1	8.128	9.00	9.0	197	209	138	10.0	377	235				3670
215	INF U	11 12 82	11.7	8.171	8.10	9.1	303	69	242	11.0	379					3830
225	INF U	11 15 82	3.9	8.129	7.40	7.8		166		8.5		378				

FIELD DATA : PITTSFIELD TREATMENT PLANT (continued)

S.NO	LOC&TYP	DATE	A.TEMP	FLOW	C.pH	G.TEMP	TSSF	TSSL	VSS	SM	BODF	BODL	DO	CL	FTP	MLSS
601	EFF U	9 17 82			7.90	6.0	10.4			T	2.5		9.30	1.5		
603	EFF U	9 20 82			7.60	5.0	11.1			T	2.4		9.30	1.4	0.89	
605	EFF U	9 21 82			7.40	5.0	11.8			T	1.4		9.00	1.2	0.82	
607	EFF U	9 22 82			7.65	7.0	10.7			T	2.0		9.10	1.3	0.77	
609	EFF U	9 23 82			7.60	5.5	9.8			T	2.7		8.60	1.8		
611	EFF U	9 24 82			7.50	6.0	11.7			T	2.4		9.10	1.5		
613	EFF U	9 27 82			7.60	6.5	14.6			T	2.2		8.90	1.75		
615	EFF U	9 28 82			7.40	6.0	14.6			T	1.7		9.20	1.75	0.93	
617	EFF U	9 29 82			7.60	7.7	9.2			T	3.2		9.50	1.7	0.98	
619	EFF U	9 30 82			7.60	5.8	12.7			T	2.3		9.00	1.2	1.06	
621	EFF U	10 1 82			7.40	5.6	6.6			T	2.0		8.70	1.0		
623	EFF U	10 4 82			7.60	6.8	10.6	10.1		T	1.7	2.3	8.90	1.6	1.47	
627	EFF U	10 5 82			7.40	5.0	7.7			T	1.9		9.10	1.5	1.44	
629	EFF U	10 6 82			7.50	5.3	7.1			T	1.8		8.90	1.9	1.35	
639	EFF U	10 7 82			7.60	5.0	5.2			T	4.3		9.20	1.5	1.31	
641	EFF U	10 8 82			7.60	7.0	7.8			T	2.6		8.80	1.1		
653	EFF U	10 12 82			7.25	5.3	11.0	11.9		T	1.6	4.7	9.50	1.6	2.36	
671	EFF U	10 13 82			7.40	6.0	45.0	10.8		T	2.0		9.20	1.3	2.58	
673	EFF U	10 14 82			7.40	5.5	15.0	12.1		T	2.6	3.9	9.00	1.2	2.93	
683	EFF U	10 15 82			7.70	6.3	11.6	12.2		T	3.8		9.30			
685	EFF U	10 18 82			7.60	5.0	11.0	11.3		T	3.2		10.00			
699	EFF U	10 19 82			7.50	5.0	8.8	8.9		T	2.4		9.60			
701	EFF U	10 20 82			7.50	6.7	11.9	13.3		T	4.2	6.3	9.60			
711	EFF U	10 21 82			7.90	6.3	9.0	13.0		T	4.1		9.50			
713	EFF U	10 22 82			7.70	5.0	8.7	14.7		T	4.0		9.70			
723	EFF U	10 25 82			7.60	5.0	9.2	17.3		T	2.2	4.6	9.80			
733	EFF U	10 26 82			7.30	5.2	8.6	14.2		T	3.8		9.80			
735	EFF U	10 27 82			7.50	5.6	8.6	14.1		T	2.8	6.4	9.80			
745	EFF U	10 28 82			7.60	5.2	14.0	6.7		T	3.4		9.50			
747	EFF U	10 29 82			7.60	5.5	9.5	6.9		T	5.1		9.50			
757	EFF U	11 1 82			7.60	5.8	7.8	10.9		0.3	2.5	10.3	8.90			
765	EFF U	11 2 82			7.40	5.8	9.5	8.0		T	1.6		9.20			
767	EFF U	11 3 82			7.50	7.0	5.8			T	2.7	8.7	9.00			
779	EFF U	11 4 82			7.60	7.0	10.1	12.4		T	3.2		8.80			
781	EFF U	11 5 82			7.50	6.0	5.0	14.5		T	2.8		9.00			
791	EFF U	11 8 82			7.30	5.5	11.3	10.3		T	2.9	5.9	9.90			
801	EFF U	11 9 82			7.30	5.2	6.4	5.2		T	2.8		9.80			
803	EFF U	11 10 82			7.50	5.5	11.8	9.6		T	3.9	7.0	9.80			
815	EFF U	11 12 82			7.60	7.0	12.2	4.1		T	6.8		9.50			
825	EFF U	11 15 82			7.70	6.0	12.8	6.1		T	3.2	7.5	9.80			

NOTE : T indicates trace amounts.

FIELD DATA : MEDFIELD TREATMENT PLANT

S.NO	LOC&TYP	DATE	A.TEMP	FLOW	G.pH	C.pH	G.TEMP	C.TEMP	TSSF	TSSL	VSS	SM	BODF	BODL	DO	FTP	MLSS
25	INF U	10 4 82	23.9	0.401	6.90		17.0		162		110	14.0			5.10		6060
31	INF U	10 5 82	23.9	0.314	7.10		17.0		164		124	15.0			5.00		5500
33	INF U	10 6 82	23.9	0.296	7.00		17.5		232		176	12.0			5.10		5980
43	INF U	10 7 82	21.1	0.360	7.00		18.0					10.0	705		4.50		5860
45	INF U	10 8 82	15.6	0.345	7.35		18.0		136		103	8.5			5.65		5660
57	INF U	10 12 82	15.6	0.305	6.90		15.0		150	165	114	16.0		44.8	6.10		5760
75	INF U	10 13 82	15.6	0.405	6.90		16.0		298		226	10.0	399		6.90	8.5	5580
77	INF U	10 14 82	18.3	0.361	6.80		16.5		268		203	10.0			6.80		5840
87	INF U	10 15 82	18.3	0.380	6.85		16.0		144		109	11.0			6.10		5780
89	INF U	10 18 82	10.0	0.246	7.00		15.0	9.0	204	166	155	7.0			4.50	5.65	5980
103	INF U	10 19 82	12.8	0.328	7.30		15.5		188		152	8.5			6.00		5120
105	INF U	10 20 92	18.3	0.318	6.95		16.0	14.0	174		139	7.0	122		4.50		5500
115	INF U	10 21 82	18.3	0.358	6.95		16.0		148		118	10.0			6.50		5400
117	INF U	10 22 82	10.0	0.330	7.20		16.0		180		144	6.0			5.70	1.15	5780
125	INF U	10 25 82	10.0	0.407	7.00		14.5		234	252	187	7.5		219	6.40		5840
137	INF U	10 26 82	7.2	0.325	7.10		15.0		180		130	15.0			4.50		5400
139	INF U	10 27 82	10.0	0.303	7.10		15.0	9.0	162		117	6.5	88		5.10		5620
149	INF U	10 28 82	15.6	0.374	6.80		13.5		178		128	14.0			5.50		4420
151	INF U	10 29 82	18.3	0.355	7.20		15.0		128		99	8.5			5.10	5.00	5620
159	INF U	11 1 82	21.1	0.160	7.00		16.0		164	143	119	8.5		228	6.00		5460
169	INF U	11 2 82	21.1	0.348	7.00		16.0		188		148	9.5			6.30		5860
171	INF U	11 3 82	18.3	0.347	6.90		16.5		124		98	8.0			6.20	0.00	5660
183	INF U	11 4 82	20.0	0.373	7.00		16.0		254		201				6.10		5460
185	INF U	11 5 82	17.2	0.350	7.00		17.0		236		186	20.0	303	144	6.70		5940
205	INF U	11 9 82	13.9	0.382	7.00	6.90	15.0	16.0	332		242	16.0			3.50		5660
207	INF U	11 10 82	15.6	0.370	7.00	6.90	14.0	15.0	326		238	15.5	362		5.40		5620
219	INF U	11 12 82	15.6	0.315	6.90	6.90	15.0	15.0	132	418	96	14.0			6.30	8.00	6100
227	INF U	11 15 82	8.9	0.336	7.00	7.15	13.5	11.0	114	52.7	83	7.5		285	4.80		5700
233	INF U	11 16 82	4.4	0.435	7.00	7.00	12.5	10.0	132		110	9.0			5.30		5620
235	INF U	11 17 82	5.0	0.384	7.00	7.00	12.0	12.0	236		196	8.5	159		5.80		5680
241	INF U	11 18 82	10.0	0.417	7.00	7.00	12.5	12.5	154	69	128	10.0			7.10		5380
243	INF U	11 19 82	6.1	0.392	7.00	7.10	13.0	12.0	246	191	204	15.0			7.15	5.03	5700
251	INF U	11 23 82	10.0	0.401	6.85	6.90	14.5	13.5	218		178	19.0	298		5.60		5000

FIELD DATA : MEDFIELD TREATMENT PLANT (continued)

S.NO	LOC&TYP	DATE	A.TEMP	FLOW	G.pH	C.pH	G.TEMP	C.TEMP	TSSF	TSSL	VSS	SM	BODF	BODL	DO	FTP	MLSS
263	INF U	11 29 82	10.0	0.310	6.90		13.0		194		160	20.0		180	5.70		4780
271	INF U	11 30 82	10.0	0.385	7.00	7.00	12.5	12.5	178	308	146	19.0			5.20		5600
273	INF U	12 1 82	14.4	0.353	7.00	7.00	13.0	13.0	158	215	130	9.0			6.60		4800
279	INF U	12 2 82	15.6	0.378	6.90	6.90	13.5	14.0	138	197	113	9.0			6.20	6.60	4820
281	INF U	12 3 82	15.6	0.360	7.00		13.5		198		162	8.0			5.90		5440
287	INF U	12 6 82	20.0	0.250	6.90		14.0		226	279	185	10.0			5.00		5420
289	INF U	12 7 82	15.6	0.373	6.90		14.0		174	316	128	9.0	445	178	5.40		3160
291	INF U	12 8 82	12.8	0.371	6.90		14.5		162	316	120	8.0			5.10		5000
293	INF U	12 9 82	6.1	0.367	7.00		12.5		132	165	98	9.5			5.70		5320
295	INF U	12 10 82	- 9.4	0.354	7.00		13.0		142		105	9.0			4.50	6.70	5360
297	INF U	12 13 82	-15.0	0.311	7.10		9.0		186	126	138	7.0			6.40		5920
299	INF U	12 14 82	- 9.4	0.367	7.00		11.0		178	160	132	8.5			7.80	5.80	4900
300	INF U	12 15 82	3.3	0.351	6.90		11.0		214	107	158	10.0	289		7.20		5260
625	EFF U	10 4 82			7.20		17.5	19.0	2.0	3.0					6.70		
631	EFF U	10 5 82			7.20		17.0		1.6						6.20		
633	EFF U	10 6 82			7.30		18.5		1.4						6.40		
643	EFF U	10 7 82			7.40		17.0		3.6				0.95		6.10		
645	EFF U	10 8 82			7.30		17.0		1.4						6.85		
657	EFF U	10 12 82			7.20		15.0		5.2	1.9				4.6	6.60		
675	EFF U	10 13 82			7.30		15.5		1.4				0.80		7.00	0.60	
677	EFF U	10 14 82			7.20		16.0		2.2						7.00		
687	EFF U	10 15 82			7.20		16.5		3.2						6.80		
689	EFF U	10 18 82			7.20		16.0	14.0	2.4	2.4					6.30	0.45	
703	EFF U	10 19 82			7.40		16.5		0.8						6.80		
705	EFF U	10 20 82			7.30		15.0	15.0	4.0				3.20		6.10		
715	EFF U	10 21 82			7.30		16.0		0.8						6.90		
717	EFF U	10 22 82			7.20		15.0		2.4						6.40	0.45	
725	EFF U	10 25 82			7.30		13.5		0.8						6.70		
737	EFF U	10 26 82			7.30		13.5	13.0	2.0						6.60		
739	EFF U	10 27 82			7.20		13.0		1.8				2.30		6.70		
749	EFF U	10 28 82			7.20		14.0		1.8						6.30		
751	EFF U	10 29 82			7.20		14.0		3.2						6.50	0.92	

FIELD DATA : MEDFIELD TREATMENT PLANT (continued)

S.NO	LOC&TYP	DATE	A.TEMP	FLOW	G.pH	C.pH	G.TEMP	C.TEMP	TSSF	TSSL	VSS	SM	BODF	BODL	DO	FTP	MLSS
759	EFF U	11 1 82			7.30		16.0		2.0	5.4				7.3	6.70		
769	EFF U	11 2 82			7.30		17.0		2.4						6.80		
771	EFF U	11 3 82			7.20		16.5		2.0						6.70	0.52	
783	EFF U	11 4 82			7.25		17.0		2.0				2.0		6.40		
785	EFF U	11 5 82			7.20		16.0		0.6					7.5	7.00		
805	EFF U	11 9 82			7.20		14.0		2.0						6.90		
807	EFF U	11 10 82			7.20		13.0		1.6				0.8		6.80		
817	EFF U	11 11 82															
819	EFF U	11 12 82			7.20		14.0		0.6	2.8					6.90	0.60	
827	EFF U	11 15 82			7.15	7.15	13.0	12.0	1.2	4.6				9.7	6.70		
833	EFF U	11 16 82			7.20	7.20	12.0	12.0	2.0						6.40		
835	EFF U	11 17 82			7.00	7.00	12.0	12.0	2.2				1.6		6.90		
841	EFF U	11 18 82			6.95	6.95	12.0	12.0	4.0	8.2					7.40		
843	EFF U	11 19 82			6.95	7.00	13.0	11.5	1.8	12.6					7.30	2.40	
851	EFF U	11 23 82			7.00		14.0		2.4				3.6		6.20	2.60	
863	EFF U	11 29 82			7.00		11.5		1.4					5.5	6.20		
871	EFF U	11 30 82			7.00	7.00	11.5	11.5	1.2	1.2					6.30		
873	EFF U	12 1 82			6.90	6.90	13.0	13.0	1.6	1.1			2.3		6.70		
879	EFF U	12 2 82			6.90	6.90	14.0	14.0		6.1					6.50		
881	EFF U	12 3 82			7.00		13.5		0.8	1.7					6.30	4.30	
887	EFF U	12 6 82			7.00		14.5		1.4	2.6					6.40		
889	EFF U	12 7 82			7.00		13.0		2.6	5.2				0	6.20		
891	EFF U	12 8 82			7.00		13.5		3.6	5.3			2.5		6.40		
893	EFF U	12 9 82			7.00		11.5		2.0	7.9					6.90		
895	EFF U	12 10 82			7.00		11.0		2.2						6.80	3.70	
897	EFF U	12 13 82			6.90		9.0		4.4	1.9					6.60		
899	EFF U	12 14 82			6.90		8.0		2.2	7.5					6.80	3.40	
900	EFF U	12 15 82			6.90		10.0		3.2	11.1			2.5	2.1	6.90		

APPENDIX E : Correlation Coefficients

```
              CORRELATION COEFFICIENTS : FITCHBURG TREATMENT PLANT
              ----------------------------------------------------
                        (cases with aluminum salt addition)

       ------------------------------------------------------------------

        VARIABLE        MEAN      STD DEV      N     CORR  T-STAT    SIGNIF
       ------------------------------------------------------------------

        1.AG.FR        .91980    .43208 -1   20    .1782   .76830     .4523
       12.PFR          .82700    .82502 -1

        1.AG.FR        .91980    .43208 -1   20   -.0342 -.14519     .8862
       13.TOCFR        .76040    .18596

        1.AG.FR        .91653    .41766 -1   19   -.2691 -1.1521     .2652
       14.TSPFR        .80174    .18315

        1.AG.FR        .91653    .41766 -1   19   -.2790 -1.1978     .2474
       15.VSSFR        .80689    .23470

        1.AG.FR        .91980    .43208 -1   20    .1026   .43777     .6668
       16.BODFR        .31705   2.4112

        1.AG.FR        .91980    .43208 -1   20   -.3749 -1.7156     .1034
       17.TURBFR       .24345   2.3992

        2.AL.FR        .55608    .27247      24    .1825   .87042     .3935
       12.PFR          .82679    .10471

        2.AL.FR        .55608    .27247      24    .1322   .62541     .5381
       13.TOCFR        .75196    .17758

        2.AL.FR        .54626    .27422      23   -.3445 -1.6816     .1075
       14.TSPFR        .81252    .16772

        2.AL.FR        .54626    .27422      23   -.3744 -1.8502     .0784
       15.VSSFR        .82430    .21675

        2.AL.FR        .55608    .27247      24   -.2159 -1.0372     .3109
       16.BODFR        .41742   2.2035

        2.AL.FR        .55608    .27247      24   -.2187 -1.0511     .3046
       17.TURBFR       .35375   2.1953

        3.AS.FR        .10650    .38584      20    .3927  1.8116      .0868
       12.PFR          .82270    .11200

        3.AS.FR        .10650    .38584      20    .0698   .29680     .7700
       13.TOCFR        .75025    .19275
```

```
        CORRELATION COEFFICIENTS : FITCHBURG TREATMENT PLANT (contd.)
        -------------------------------------------------------------
                      (cases with aluminum salt addition)

   ------------------------------------------------------------------

     VARIABLE         MEAN      STD DEV       N     CORR  T-STAT    SIGNIF
   ------------------------------------------------------------------

    3.AS.FR          .10650     .38584       20   -.1105 -.47181    .6427
   14.TSPFR          .81520     .18012

    3.AS.FR          .10650     .38584       20   -.1623 -.69787    .4942
   15.VSSFR          .82190     .23226

    3.AS.FR          .10650     .38584       20    .1099  .46927    .6445
   16.BODFR          .34530    2.4143

    3.AS.FR          .10650     .38584       20   -.3661 -1.6692    .1124
   17.TURBFR         .78755     .24177

    4.CD.FR          .88648     .63856 -1    23   -.0861 -.39622    .6959
   12.PFR            .83974     .85181 -1

    4.CD.FR          .88648     .63856 -1    23   -.1007 -.46368    .6476
   13.TOCFR          .75030     .18138

    4.CD.FR          .88495     .64929 -1    22    .4158  2.0445    .0543
   14.TSPFR          .80941     .17098

    4.CD.FR          .88495     .64929 -1    22    .4793  2.4421    .0240
   15.VSSFR          .82123     .22134

    4.CD.FR          .88648     .63856 -1    23   -.2558 -1.2126    .2388
   16.BODFR          .39339    2.2498

    4.CD.FR          .88648     .63856 -1    23   -.0611 -.28069    .7817
   17.TURBFR         .32804    2.2410

    5.CR.FR          .75767     .29521       24   -.0405 -.19009    .8510
   12.PFR            .82679     .10471

    5.CR.FR          .75767     .29521       24   -.1528 -.72502    .4761
   13.TOCFR          .75196     .17758

    5.CR.FR          .74883     .29858       23   -.1055 -.48626    .6318
   14.TSPFR          .81252     .16772
```

```
    CORRELATION COEFFICIENTS : FITCHBURG TREATMENT PLANT (contd.)
    --------------------------------------------------------------
                  (cases with aluminum salt addition)

 --------------------------------------------------------------------

  VARIABLE        MEAN      STD DEV       N     CORR   T-STAT    SIGNIF
 --------------------------------------------------------------------

  5.CR.FR        .74883     .29858       23   -.2429 -1.1474     .2641
 15.VSSFR        .82430     .21675

  5.CR.FR        .75767     .29521       24   -.1271 -.60092     .5540
 16.BODFR        .41742     2.2035

  5.CR.FR        .75767     .29521       24   -.1711 -.81447     .4241
 17.TURBFR       .35375     2.1953

  6.CU.FR        .91467     .41401 -1    24   -.2436 -1.1781     .2513
 12.PFR          .82679     .10471

  6.CU.FR        .91467     .41401 -1    24    .1137  .53662     .5969
 13.TOCFR        .75196     .17758

  6.CU.FR        .91191     .40021 -1    23   -.4790 -2.5006     .0207
 14.TSPFR        .81252     .16772

  6.CU.FR        .91191     .40021 -1    23   -.5603 -3.0996     .0054
 15.VSSFR        .82430     .21675

  6.CU.FR        .91467     .41401 -1    24   -.3825 -1.9419     .0651
 16.BODFR        .41742     2.2035

  6.CU.FR        .91467     .41401 -1    24   -.3815 -1.9360     .0658
 17.TURBFR       .35375     2.1953

  7.HG.FR        .32710     .11830       20    .1067  .45509     .6545
 12.PFR          .81605     .11004

  7.HG.FR        .32710     .11830       20    .1318  .56421     .5796
 13.TOCFR        .74985     .19287

  7.HG.FR        .33216     .11929       19   -.0572 -.23605     .8162
 14.TSPFR        .80858     .18253

  7.HG.FR        .33216     .11929       19    .0747  .30887     .7612
 15.VSSFR        .81516     .23661
```

CORRELATION COEFFICIENTS : FITCHBURG TREATMENT PLANT (contd.)

(cases with aluminum salt addition)

VARIABLE	MEAN	STD DEV	N	CORR	T-STAT	SIGNIF
7.HG.FR 16.BODFR	.32710 .31245	.11830 2.4100	20	-.0845	-.35963	.7233
7.HG.FR 17.TURBFR	.32710 .24630	.11830 2.4002	20	.1983	.85852	.4019
8.PB.FR 12.PFR	.68642 .82679	.38517 .10471	24	-.0609	-.28622	.7774
8.PB.FR 13.TOCFR	.68642 .75196	.38517 .17758	24	-.1499	-.71123	.4844
8.PB.FR 14.TSPFR	.67387 .81252	.38878 .16772	23	-.3488	-1.7053	.1029
8.PB.FR 15.VSSFR	.67387 .82430	.38878 .21675	23	-.3110	-1.4993	.1487
8.PB.FR 16.BODFR	.68642 .41742	.38517 2.2035	24	-.1700	-.80917	.4271
8.PB.FR 17.TURBFR	.68642 .35375	.38517 2.1953	24	-.1963	-.93891	.3580
9.SB.FR 12.PFR	.69952 -1 .83057	.19501 .10610	21	.4180	2.0054	.0594
9.SB.FR 13.TOCFR	.69952 -1 .73938	.19501 .18448	21	-.1953	-.86808	.3962
9.SB.FR 14.TSPFR	.85000 -1 .82750	.18715 .14448	20	-.0629	-.26743	.7922
9.SB.FR 15.VSSFR	.85000 -1 .84205	.18715 .20311	20	-.0409	-.17350	.8642
9.SB.FR 16.BODFR	.69952 -1 .85967	.19501 .17191	21	.1739	.76990	.4508

```
      CORRELATION COEFFICIENTS : FITCHBURG TREATMENT PLANT (contd.)
      -------------------------------------------------------------
                    (cases with aluminum salt addition)

  --------------------------------------------------------------------
   VARIABLE        MEAN     STD DEV      N     CORR  T-STAT     SIGNIF
  --------------------------------------------------------------------

   9.SB.FR        .69952 -1 .19501       21    .3335  1.5419      .1396
  17.TURBFR       .28433     2.3452

  10.SE.FR        .97786 -1 .38771       14    .0292  .10116      .9211
  12.PFR          .86614     .66663 -1

  10.SE.FR        .97786 -1 .38771       14  -.2167 -.76908       .4567
  13.TOCFR        .77814     .78759 -1

  10.SE.FR        .16238     .31552      13    .4477  1.6604      .1251
  14.TSPFR        .75338     .20420

  10.SE.FR        .16238     .31552      13    .3009  1.0463      .3179
  15.VSSFR        .76138     .27483

  10.SE.FR        .97786 -1 .38771       14    .6570  3.0192      .0107
  16.BODFR        .50714 -1 2.8710

  10.SE.FR        .97786 -1 .38771       14    .6209  2.7437      .0178
  17.TURBFR      -.23286 -1 2.8558

  11.ZN.FR        .44906     .20278      16    .0194  .72672 -1   .9431
  12.PFR          .83906     .74592 -1

  11.ZN.FR        .44906     .20278      16  -.0057 -.21433 -1   .9832
  13.TOCFR        .74337     .21628

  11.ZN.FR        .45487     .20852      15    .3829  1.4944      .1590
  14.TSPFR        .79127     .20394

  11.ZN.FR        .45487     .20852      15    .3370  1.2908      .2193
  15.VSSFR        .79260     .26001

  11.ZN.FR        .44906     .20278      16  -.0243 -.91069 -1   .9287
  16.BODFR        .16069    2.6896

  11.ZN.FR        .44906     .20278      16    .1627  .61687      .5472
  17.TURBFR       .83813 -1 2.6749
```

CORRELATION COEFFICIENTS : FITCHBURG TREATMENT PLANT (contd.)

(cases without aluminum salt addition)

VARIABLE	MEAN	STD DEV	N	CORR	T-STAT	SIGNIF
1.AG.FR 12.PFR	.90085 .42640	.10752 .32158	20	.8796	7.8445	.0000
1.AG.FR 13.TOCFR	.90085 .24480	.10752 2.3902	20	.9565	13.912	.0000
1.AG.FR 14.TSPFR	.90085 .85735	.10752 .12261	20	-.2138	-.92858	.3654
1.AG.FR 15.VSSFR	.90085 .33585	.10752 2.4122	20	-.1580	-.67901	.5058
1.AG.FR 16.BODFR	.90085 .88425	.10752 .55654 -1	20	-.1690	-.72760	.4762
1.AG.FR 17.TURBFR	.90085 .29460	.10752 2.4048	20	.0271	.11491	.9098
2.AL.FR 12.PFR	.60004 .43122	.38531 .28583	27	.3084	1.6207	.1176
2.AL.FR 13.TOCFR	.60004 .36526	.38531 2.0574	27	.1450	.73267	.4706
2.AL.FR 14.TSPFR	.60004 .45900	.38531 2.0733	27	.2538	1.3121	.2014
2.AL.FR 15.VSSFR	.60004 .72593 -1	.38531 2.8765	27	.0903	.45351	.6541
2.AL.FR 16.BODFR	.60004 .48474	.38531 2.0762	27	.2631	1.3636	.1848
2.AL.FR 17.TURBFR	.60004 .49593 -1	.38531 2.8711	27	.1314	.66285	.5135
3.AS.FR 12.PFR	-.16818 -1 .45400	.68241 .30488	22	-.2227	-1.0214	.3193
3.AS.FR 13.TOCFR	-.16818 -1 .30050	.68241 2.2807	22	-.0601	-.26913	.7906

```
        CORRELATION COEFFICIENTS : FITCHBURG TREATMENT PLANT (contd.)
        -------------------------------------------------------------
                   (cases without aluminum salt addition)

    ----------------------------------------------------------------------

      VARIABLE        MEAN       STD DEV      N      CORR  T-STAT    SIGNIF
    ----------------------------------------------------------------------

      3.AS.FR       -.16818 -1  .68241
     14.TSPFR        .84818     .12014       22   -.2434 -1.1224     .2750

      3.AS.FR       -.16818 -1  .68241
     15.VSSFR        .37377    2.2977        22   -.0067 -.29999 -1  .9764

      3.AS.FR       -.16818 -1  .68241
     16.BODFR        .87955     .57246 -1    22   -.4569 -2.2971     .0325

      3.AS.FR       -.16818 -1  .68241
     17.TURBFR       .83736     .15205       22   -.1924 -.87689     .3910

      4.CD.FR        .81513     .24559
     12.PFR          .49070     .18115       23    .1088  .50161     .6212

      4.CD.FR        .81513     .24559
     13.TOCFR        .74787     .16460       23    .1290  .59607     .5575

      4.CD.FR        .81513     .24559
     14.TSPFR        .38365    2.2448        23   -.0770 -.35403     .7268

      4.CD.FR        .81513     .24559
     15.VSSFR       -.71652 -1 3.1033        23   -.1310 -.60542     .5514

      4.CD.FR        .81513     .24559
     16.BODFR        .41013    2.2483        23   -.0829 -.38102     .7070

      4.CD.FR        .81513     .24559
     17.TURBFR      -.97391 -1 3.0967        23   -.1652 -.76736     .4514

      5.CR.FR        .58115    1.2596
     12.PFR          .43122     .28583       27    .2173  1.1130     .2763

      5.CR.FR        .58115    1.2596
     13.TOCFR        .36526    2.0574        27    .0222  .11115     .9124

      5.CR.FR        .58115    1.2596
     14.TSPFR        .45900    2.0733        27   -.0161 -.80345 -1  .9366
```

```
           CORRELATION COEFFICIENTS : FITCHBURG TREATMENT PLANT (contd.)
           -------------------------------------------------------------
                      (cases without aluminum salt addition)

       ---------------------------------------------------------------------

        VARIABLE          MEAN      STD DEV        N      CORR   T-STAT       SIGNIF
       ---------------------------------------------------------------------

         5.CR.FR        .58115      1.2596
        15.VSSFR        .72593 -1  2.8765       27   -.0532 -.26645           .7921

         5.CR.FR        .58115      1.2596
        16.BODFR        .48474      2.0762       27   -.0137 -.68307 -1     .9461

         5.CR.FR        .58115      1.2596
        17.TURBFR       .49593 -1  2.8711       27   -.0568 -.28457           .7783

         6.CU.FR        .76189      .27052
        12.PFR          .43122      .28583       27    .8099   6.9032          .0000

         6.CU.FR        .76189      .27052
        13.TOCFR        .36526      2.0574       27    .8490   8.0351          .0000

         6.CU.FR        .76189      .27052
        14.TSPFR        .45900      2.0733       27   -.0620 -.31037           .7589

         6.CU.FR        .76189      .27052
        15.VSSFR        .72593 -1  2.8765       27   -.1536 -.77702           .4444

         6.CU.FR        .76189      .27052
        16.BODFR        .48474      2.0762       27   -.0555 -.27782           .7834

         6.CU.FR        .76189      .27052
        17.TURBFR       .49593 -1  2.8711       27   -.1229 -.61942           .5412

         7.HG.FR        .37428      .36347
        12.PFR          .41156      .32418       18    .6159   3.1268          .0065

         7.HG.FR        .37428      .36347
        13.TOCFR        .19572      2.5221       18    .7470   4.4941          .0004

         7.HG.FR        .37428      .36347
        14.TSPFR        .85689      .11117       18    .3251   1.3753          .1880

         7.HG.FR        .37428      .36347
        15.VSSFR        .27350      2.5415       18   -.1946 -.79366           .4390
```

```
   CORRELATION COEFFICIENTS : FITCHBURG TREATMENT PLANT (contd.)
   -----------------------------------------------------------------
                 (cases without aluminum salt addition)

 -----------------------------------------------------------------------

  VARIABLE        MEAN      STD DEV      N     CORR   T-STAT    SIGNIF
 -----------------------------------------------------------------------

   7.HG.FR       .37428     .36347      18   -.0295  -.11807     .9075
  16.BODFR       .88000     .53068 -1

   7.HG.FR       .37428     .36347      18   -.1583  -.64122     .5305
  17.TURBFR      .24861    2.5355

   8.PB.FR       .25685    2.0554       27    .2483   1.2818     .2117
  12.PFR         .43122     .28583

   8.PB.FR       .25685    2.0554       27    .0805   .40384     .6898
  13.TOCFR       .36526    2.0574

   8.PB.FR       .25685    2.0554       27    .0603   .30210     .7651
  14.TSPFR       .45900    2.0733

   8.PB.FR       .25685    2.0554       27   -.0042  -.20843 -1  .9835
  15.VSSFR       .72593 -1 2.8765

   8.PB.FR       .25685    2.0554       27    .0620   .31080     .7585
  16.BODFR       .48474    2.0762

   8.PB.FR       .25685    2.0554       27   -.0071  -.35324 -1  .9721
  17.TURBFR      .49593 -1 2.8711

   9.SB.FR       .12970     .28568      27   -.0171  -.85312 -1  .9327
  12.PFR         .43122     .28583

   9.SB.FR       .12970     .28568      27    .0984   .49461     .6252
  13.TOCFR       .36526    2.0574

   9.SB.FR       .12970     .28568      27    .3661   1.9673     .0603
  14.TSPFR       .45900    2.0733

   9.SB.FR       .12970     .28568      27    .2427   1.2508     .2226
  15.VSSFR       .72593 -1 2.8765

   9.SB.FR       .12970     .28568      27    .3661   1.9669     .0604
  16.BODFR       .48474    2.0762
```

CORRELATION COEFFICIENTS : FITCHBURG TREATMENT PLANT (contd.)

(cases without aluminum salt addition)

VARIABLE	MEAN	STD DEV	N	CORR	T-STAT	SIGNIF
9.SB.FR 17.TURBFR	.12970 .49593 -1	.28568 2.8711	27	-.0088	-.44188 -1	.9651
10.SE.FR 12.PFR	.12043 .47829	.28910 .25720	7	.7894	2.8756	.0348
10.SE.FR 13.TOCFR	.12043 .85429	.28910 .66415 -1	7	.1446	.32679	.7571
10.SE.FR 14.TSPFR	.12043 -.62429	.28910 4.0905	7	-.0821	-.18424	.8611
10.SE.FR 15.VSSFR	.12043 -2.1634	.28910 5.2853	7	-.3053	-.71686	.5055
10.SE.FR 16.BODFR	.12043 -.64029	.28910 4.0833	7	-.0826	-.18526	.8603
10.SE.FR 17.TURBFR	.12043 -2.1680	.28910 5.2820	7	.0948	.21293	.8398
11.ZN.FR 12.PFR	.46911 .48689	.29724 .17886	9	-.3148	-.87746	.4093
11.ZN.FR 13.TOCFR	.46911 .81300	.29724 .72384 -1	9	.6270	2.1295	.0707
11.ZN.FR 14.TSPFR	.46911 .85311	.29724 .10527	9	.5449	1.7195	.1292
11.ZN.FR 15.VSSFR	.46911 -.33033	.29724 3.5899	9	-.1928	-.51975	.6193
11.ZN.FR 16.BODFR	.46911 .88567	.29724 .47045 -1	9	-.2383	-.64904	.5370
11.ZN.FR 17.TURBFR	.46911 -.32767	.29724 3.5908	9	-.5918	-1.9427	.0932

```
          CORRELATION COEFFICIENTS : PITTSFIELD TREATMENT PLANT
          ------------------------------------------------------
                   (cases with aluminum salt addition)

------------------------------------------------------------------------

  VARIABLE        MEAN     STD DEV      N     CORR   T-STAT      SIGNIF
------------------------------------------------------------------------

  1.AG.FR        .90479   .42671 -1
 12.PFR          .84900   .75094 -1    14   -.1532  -.53689       .6012

  1.AG.FR        .90275   .41440 -1
 13.TOCFR        .80150   .76599 -1    16    .3439  1.3703        .1922

  1.AG.FR        .91029   .42574 -1
 14.TSPFR        .94071   .63945 -1     7   -.2173  -.49779       .6398

  1.AG.FR
 15.VSSFR                               0

  1.AG.FR        .90967   .46603 -1
 16.BODFR        .98933   .30768 -2     6    .0121   .24178 -1    .9819

  2.AL.FR        .94862   .23483 -1
 12.PFR          .83931   .79801 -1    16    .5431  2.4200        .0297

  2.AL.FR        .94988   .23321 -1
 13.TOCFR        .80041   .72889 -1    17    .0052   .20054 -1    .9843

  2.AL.FR        .94750   .26774 -1
 14.TSPFR        .93837   .59570 -1     8    .8412  3.8105        .0089

  2.AL.FR
 15.VSSFR                               0

  2.AL.FR        .94286   .25202 -1
 16.BODFR        .99000   .33166 -2     7   -.4287 -1.0611        .3372

  3.AS.FR        .64747   .13276
 12.PFR          .84587   .78017 -1    15    .4412  1.7724        .0997

  3.AS.FR        .64100   .13084
 13.TOCFR        .79694   .73811 -1    16    .0331   .12387       .9032

  3.AS.FR        .61171   .15139
 14.TSPFR        .93286   .62095 -1     7    .1107   .24913       .8132

  3.AS.FR
 15.VSSFR                               0
```

```
           CORRELATION COEFFICIENTS : PITTSFIELD TREATMENT PLANT
           -----------------------------------------------------
                     (cases with aluminum salt addition)

---------------------------------------------------------------------

  VARIABLE         MEAN      STD DEV       N      CORR  T-STAT    SIGNIF
---------------------------------------------------------------------

  3.AS.FR         .57617    .12996         6  -.7098 -2.0153      .1141
 16.BODFR         .99083    .27142 -2

  4.CD.FR         .73194    .11877        16  -.4722 -2.0045      .0648
 12.PFR           .83931    .79801 -1

  4.CD.FR         .73029    .11520        17   .2873  1.1617      .2635
 13.TOCFR         .80041    .72889 -1

  4.CD.FR         .70875    .12297         8  -.4061 -1.0887      .3181
 14.TSPFR         .93837    .59570 -1

  4.CD.FR                                  0
 15.VSSFR

  4.CD.FR         .70157    .13100         7  -.1872 -.42613      .6877
 16.BODFR         .99000    .33166 -2

  5.CR.FR         .92575    .21871 -1     16   .1012  .38044      .7093
 12.PFR           .83931    .79801 -1

  5.CR.FR         .91606    .45367 -1     18  -.3172 -1.3381      .1996
 13.TOCFR         .80644    .75202 -1

  5.CR.FR         .92375    .22263 -1      8   .4438  1.2130      .2707
 14.TSPFR         .93837    .59570 -1

  5.CR.FR                                  0
 15.VSSFR

  5.CR.FR         .92171    .23229 -1      7  -.7334 -2.4122      .0607
 16.BODFR         .99000    .33166 -2

  6.CU.FR         .88381    .50718 -1     16   .0755  .28320      .7812
 12.PFR           .83931    .79801 -1

  6.CU.FR         .88394    .49110 -1     17   .0108  .41754 -1   .9672
 13.TOCFR         .80041    .72889 -1

  6.CU.FR         .86400    .63541 -1      8   .2876  .73543      .4898
 14.TSPFR         .93837    .59570 -1
```

```
           CORRELATION COEFFICIENTS : PITTSFIELD TREATMENT PLANT
           -------------------------------------------------
                    (cases with aluminum salt addition)

-------------------------------------------------------------------

  VARIABLE        MEAN      STD DEV      N      CORR   T-STAT    SIGNIF
-------------------------------------------------------------------
   6.CU.FR
  15.VSSFR                               0

   6.CU.FR       .85357    .60789 -1     7   -.6704 -2.0204      .0993
  16.BODFR       .99000    .33166 -2

   7.HG.FR       .54700    .31456       15    .3307  1.2632      .2287
  12.PFR         .83600    .81456 -1

   7.HG.FR       .55606    .30605       16    .3172  1.2517      .2312
  13.TOCFR       .80212    .74925 -1

   7.HG.FR       .54714    .29981        7    .6439  1.8817      .1186
  14.TSPFR       .93629    .64025 -1

   7.HG.FR
  15.VSSFR                               0

   7.HG.FR       .50833    .30856        6   -.2350 -.48358      .6540
  16.BODFR       .98983    .36009 -2

   8.PB.FR       .90925    .44132 -1    16    .1536  .58151      .5701
  12.PFR         .83931    .79801 -1

   8.PB.FR       .90906    .42738 -1    17   -.0942 -.36641      .7192
  13.TOCFR       .80041    .72889 -1

   8.PB.FR       .90800    .51236 -1     8    .6729  2.2283      .0674
  14.TSPFR       .93837    .59570 -1

   8.PB.FR
  15.VSSFR                               0

   8.PB.FR       .90257    .52798 -1     7   -.6015 -1.6837      .1531
  16.BODFR       .99000    .33166 -2

   9.SB.FR       .39262    .17898       16    .4383  1.8247      .0895
  12.PFR         .83931    .79801 -1

   9.SB.FR       .38965    .17373       17   -.3318 -1.3620      .1933
  13.TOCFR       .80041    .72889 -1
```

```
            CORRELATION COEFFICIENTS : PITTSFIELD TREATMENT PLANT
            -------------------------------------------------
                      (cases with aluminum salt addition)

 -----------------------------------------------------------------

  VARIABLE        MEAN      STD DEV      N     CORR   T-STAT     SIGNIF
 -----------------------------------------------------------------

   9.SB.FR       .33375    .21878
  14.TSPFR       .93837    .59570 -1     8    .2453   .61969      .5582

   9.SB.FR
  15.VSSFR                               0

   9.SB.FR       .28686    .18793
  16.BODFR       .99000    .33166 -2     7   -.0668  -.14981      .8868

  10.SE.FR       .33256    .36151
  12.PFR         .83931    .79801 -1    16    .1760   .66894      .5144

  10.SE.FR       .18306    .70887
  13.TOCFR       .80041    .72889 -1    17    .3084   1.2557      .2284

  10.SE.FR       .25550    .41272
  14.TSPFR       .93837    .59570 -1     8   -.4427  -1.2093      .2720

  10.SE.FR
  15.VSSFR                               0

  10.SE.FR       .22000    .43239
  16.BODFR       .99000    .33166 -2     7    .8981   4.5673      .0060

  11.ZN.FR       .64606    .17284
  12.PFR         .83931    .79801 -1    16    .5183   2.2676      .0397

  11.ZN.FR       .64706    .16741
  13.TOCFR       .80041    .72889 -1    17   -.1589  -.62336      .5424

  11.ZN.FR       .60625    .22014
  14.TSPFR       .93837    .59570 -1     8    .9278   6.0922      .0009

  11.ZN.FR
  15.VSSFR                               0

  11.ZN.FR       .61043    .23744
  16.BODFR       .99000    .33166 -2     7   -.3879  -.94118      .3898
```

```
          CORRELATION COEFFICIENTS : PITTSFIELD TREATMENT PLANT
          ----------------------------------------------------
                  (cases without aluminum salt addition)

  -------------------------------------------------------------------

   VARIABLE       MEAN      STD DEV      N     CORR   T-STAT    SIGNIF
  -------------------------------------------------------------------

   1.AG.FR       .87800    .20865
  12.PFR         .53926    .10744       19    .1664   .69564     .4961

   1.AG.FR       .88368    .20988
  13.TOCFR       .84100    .59406 -1    19    .4279   1.9520     .0676

   1.AG.FR       .94560    .19945 -1
  14.TSPFR       .96380    .15469 -1    10    .4708   1.5092     .1697

   1.AG.FR
  15.VSSFR                               0

   1.AG.FR       .94422    .20644 -1
  16.BODFR       .98900    .41833 -2     9    .6730   2.4076     .0469

   2.AL.FR       .90125    .57443 -1
  12.PFR         .54065    .10476       20   -.0221  -.93952 -1  .9262

   2.AL.FR       .90280    .58804 -1
  13.TOCFR       .84020    .57932 -1    20   -.0477  -.20279     .8416

   2.AL.FR       .90660    .51191 -1
  14.TSPFR       .96380    .15469 -1    10    .6146   2.2037     .0587

   2.AL.FR
  15.VSSFR                               0

   2.AL.FR       .90878    .53802 -1
  16.BODFR       .98900    .41833 -2     9    .3260   .91238     .3919

   3.AS.FR       .39258    .50464
  12.PFR         .53726    .10650       19    .1946   .81799     .4247

   3.AS.FR       .40068    .51043
  13.TOCFR       .84200    .58943 -1    19    .0632   .26128     .7970

   3.AS.FR       .51080    .33661
  14.TSPFR       .96380    .15469 -1    10   -.3810  -1.1655     .2774

   3.AS.FR
  15.VSSFR                               0
```

```
          CORRELATION COEFFICIENTS : PITTSFIELD TREATMENT PLANT
          ---------------------------------------------------
                   (cases without aluminum salt addition)

 -------------------------------------------------------------------

  VARIABLE       MEAN      STD DEV      N     CORR  T-STAT     SIGNIF
 -------------------------------------------------------------------

  3.AS.FR       .51889    .35600        9  -.4423 -1.3049      .2332
 16.BODFR       .98900    .41833 -2

  4.CD.FR       .74125    .21454       20   .2229  .97008      .3449
 12.PFR         .54065    .10476

  4.CD.FR       .74470    .21717       20   .1458  .62514      .5397
 13.TOCFR       .84020    .57932 -1

  4.CD.FR       .70710    .26936       10   .4805 1.5498       .1598
 14.TSPFR       .96380    .15469 -1

  4.CD.FR                               0
 15.VSSFR

  4.CD.FR       .69378    .28219        9  -.0021 -.56032 -2   .9957
 16.BODFR       .98900    .41833 -2

  5.CR.FR       .86825    .79812 -1    20   .0914  .38949      .7015
 12.PFR         .54065    .10476

  5.CR.FR       .86670    .78451 -1    20   .0237  .10061      .9210
 13.TOCFR       .84020    .57932 -1

  5.CR.FR       .86200    .61977 -1    10   .2710  .79619      .4489
 14.TSPFR       .96380    .15469 -1

  5.CR.FR                               0
 15.VSSFR

  5.CR.FR       .87444    .50784 -1     9   .3095  .86112      .4177
 16.BODFR       .98900    .41833 -2

  6.CU.FR       .81085    .68335 -1    20   .2762 1.2192       .2385
 12.PFR         .54065    .10476

  6.CU.FR       .81620    .71474 -1    20   .2473 1.0830       .2931
 13.TOCFR       .84020    .57932 -1

  6.CU.FR       .81360    .94544 -1    10   .5513 1.8689       .0986
 14.TSPFR       .96380    .15469 -1
```

```
              CORRELATION COEFFICIENTS : PITTSFIELD TREATMENT PLANT
              -----------------------------------------------------
                     (cases without aluminum salt addition)

   ---------------------------------------------------------------------

    VARIABLE       MEAN      STD DEV      N     CORR  T-STAT      SIGNIF
   ---------------------------------------------------------------------

    6.CU.FR                               0
   15.VSSFR

    6.CU.FR       .79933    .88125 -1     9    .6164  2.0713       .0771
   16.BODFR       .98900    .41833 -2

    7.HG.FR       .47329    .27289       21    .3647  1.7075       .1040
   12.PFR         .54686    .10599

    7.HG.FR       .47990    .27796       21   -.2227 -.99594       .3318
   13.TOCFR       .83986    .56487 -1

    7.HG.FR       .49270    .33688       10    .3191  .95250       .3687
   14.TSPFR       .96380    .15469 -1

    7.HG.FR                               0
   15.VSSFR

    7.HG.FR       .58522    .17712        9    .5485  1.7354       .1263
   16.BODFR       .98900    .41833 -2

    8.PB.FR       .74142    .42813       19    .1527  .63700       .5326
   12.PFR         .54968    .99301 -1

    8.PB.FR       .74142    .42813       19    .1924  .80819       .4301
   13.TOCFR       .84016    .59520 -1

    8.PB.FR       .66878    .57480        9    .6012  1.9905       .0868
   14.TSPFR       .96422    .16346 -1

    8.PB.FR                               0
   15.VSSFR

    8.PB.FR       .63625    .60556        8   -.0135 -.33152 -1   .9746
   16.BODFR       .98987    .34821 -2

    9.SB.FR       .32405    .16152       20    .3789  1.7368       .0995
   12.PFR         .54065    .10476

    9.SB.FR       .31915    .16058       20    .4208  1.9682       .0646
   13.TOCFR       .84020    .57932 -1
```

```
            CORRELATION COEFFICIENTS : PITTSFIELD TREATMENT PLANT
            ----------------------------------------------------
                  (cases without aluminum salt addition)

 ------------------------------------------------------------------

  VARIABLE        MEAN      STD DEV      N     CORR  T-STAT     SIGNIF
 ------------------------------------------------------------------

  9.SB.FR        .35400    .20179       10   .1082   .30798      .7660
 14.TSPFR        .96380    .15469 -1

  9.SB.FR                                0
 15.VSSFR

  9.SB.FR        .37056    .20670        9  -.0389 -.10296      .9209
 16.BODFR        .98900    .41833 -2

 10.SE.FR        .40542    .18383       12   .1770   .56880      .5820
 12.PFR          .53808    .11297

 10.SE.FR        .40542    .18383       12   .3873  1.3286       .2135
 13.TOCFR        .84533    .54135 -1

 10.SE.FR        .43187    .22275        8   .3162   .81651      .4454
 14.TSPFR        .96325    .17194 -1

 10.SE.FR                                0
 15.VSSFR

 10.SE.FR        .42200    .23870        7   .3181   .75034      .4868
 16.BODFR        .98943    .35051 -2

 11.ZN.FR        .55759    .17849       17   .4867  2.1576       .0476
 12.PFR          .55029    .10351

 11.ZN.FR        .56376    .18495       17  -.4446 -1.9224       .0738
 13.TOCFR        .84065    .61094 -1

 11.ZN.FR        .53970    .22040       10   .5296  1.7661       .1154
 14.TSPFR        .96380    .15469 -1

 11.ZN.FR                                0
 15.VSSFR

 11.ZN.FR        .58378    .18108        9   .1287   .34339      .7414
 16.BODFR        .98900    .41833 -2
```

```
          CORRELATION COEFFICIENTS : MEDFIELD TREATMENT PLANT
          -------------------------------------------------
                   (cases with aluminum salt addition)

 ----------------------------------------------------------------

  VARIABLE        MEAN      STD DEV      N     CORR  T-STAT     SIGNIF
 ----------------------------------------------------------------

  1.AG.FR        .88200    .56065 -1     9    .2931  .81114       .4440
 12.PFR          .88589    .44650 -1

  1.AG.FR        .88200    .56065 -1     9   -.0652 -.17282       .8677
 13.TOCFR        .90500    .52233 -1

  1.AG.FR        .87457    .51185 -1     7    .1176  .26486       .8017
 14.TSPFR        .98671    .82808 -2

  1.AG.FR                                0
 15.VSSFR

  1.AG.FR        .83650    .13435 -1     2   1.0000
 16.BODFR        .98650    .17678 -1

  2.AL.FR        .93091    .44909 -1    23    .0138  .63374 -1  .9501
 12.PFR          .88822    .48634 -1

  2.AL.FR        .93091    .44909 -1    23   -.0300 -.13777       .8917
 13.TOCFR        .89217    .88438 -1

  2.AL.FR        .92852    .45885 -1    21    .0947  .41458       .6831
 14.TSPFR        .98743    .78522 -2

  2.AL.FR                                0
 15.VSSFR

  2.AL.FR        .90233    .67241 -1     3    .4207  .46377       .7235
 16.BODFR        .98233    .14434 -1

  3.AS.FR        .20544    .37343       16    .2929  1.1463       .2709
 12.PFR          .89975    .46334 -1

  3.AS.FR        .20544    .37343       16    .0184  .68690 -1  .9462
 13.TOCFR        .92431    .26249 -1

  3.AS.FR        .17767    .36903       15   -.0704 -.25455       .8031
 14.TSPFR        .98793    .86806 -2

  3.AS.FR                                0
 15.VSSFR
```

```
     CORRELATION COEFFICIENTS : MEDFIELD TREATMENT PLANT (contd.)
     ------------------------------------------------------------
                (cases with aluminum salt addition)
---------------------------------------------------------------------

  VARIABLE        MEAN      STD DEV      N     CORR   T-STAT     SIGNIF
---------------------------------------------------------------------

   3.AS.FR      .60000 -2
  16.BODFR      .97400                   1

   4.CD.FR      .83743    .25484        23   -.3729 -1.8414      .0797
  12.PFR        .88822    .48634 -1

   4.CD.FR      .83743    .25484        23   -.1962 -.91714      .3695
  13.TOCFR      .89217    .88438 -1

   4.CD.FR      .82605    .26434        21   -.0634 -.27676      .7850
  14.TSPFR      .98743    .78522 -2

   4.CD.FR
  15.VSSFR                               0

   4.CD.FR      .89367    .58731 -1      3    .9339  2.6118      .2328
  16.BODFR      .98233    .14434 -1

   5.CR.FR      .77291    .21479        22   -.2245 -1.0304      .3151
  12.PFR        .88736    .49602 -1

   5.CR.FR      .77291    .21479        22    .3564  1.7059      .1035
  13.TOCFR      .88986    .89806 -1

   5.CR.FR      .75995    .22084        20   -.0045 -.19297 -1   .9848
  14.TSPFR      .98705    .78571 -2

   5.CR.FR
  15.VSSFR                               0

   5.CR.FR      .81867    .66666 -1      3    .4200  .46283      .7240
  16.BODFR      .98233    .14434 -1

   6.CU.FR      .92457    .60228 -1     23   -.1391 -.64392      .5266
  12.PFR        .88822    .48634 -1

   6.CU.FR      .92457    .60228 -1     23    .3327  1.6165      .1209
  13.TOCFR      .89217    .88438 -1

   6.CU.FR      .92081    .61376 -1     21    .3164  1.4539      .1623
  14.TSPFR      .98743    .78522 -2
```

CORRELATION COEFFICIENTS : MEDFIELD TREATMENT PLANT (contd.)

(cases with aluminum salt addition)

VARIABLE	MEAN	STD DEV	N	CORR	T-STAT	SIGNIF
6.CU.FR			0			
15.VSSFR						
6.CU.FR	.85467	.74969 -1	3	.9973	13.594	.0467
16.BODFR	.98233	.14434 -1				
7.HG.FR	.70443	.19985	21	.2112	.94204	.3580
12.PFR	.88533	.49983 -1				
7.HG.FR	.70443	.19985	21	.1022	.44796	.6592
13.TOCFR	.88838	.91800 -1				
7.HG.FR	.69995	.20026	19	.1921	.80691	.4309
14.TSPFR	.98779	.79413 -2				
7.HG.FR			0			
15.VSSFR						
7.HG.FR	.51933	.30267	3	.1049	.10550	.9331
16.BODFR	.98233	.14434 -1				
8.PB.FR	.83695	.12432	22	.0770	.34528	.7335
12.PFR	.88736	.49602 -1				
8.PB.FR	.83695	.12432	22	-.0046	-.20565 -1	.9838
13.TOCFR	.88986	.89806 -1				
8.PB.FR	.82955	.12691	20	.1548	.66493	.5145
14.TSPFR	.98705	.78571 -2				
8.PB.FR			0			
15.VSSFR						
8.PB.FR	.70867	.18311	3	.6873	.94633	.5175
16.BODFR	.98233	.14434 -1				
9.SB.FR	.89200 -1	.22501	20	.0824	.35092	.7297
12.PFR	.88610	.51899 -1				
9.SB.FR	.89200 -1	.22501	20	.1258	.53786	.5973
13.TOCFR	.90325	.62236 -1				

```
     CORRELATION COEFFICIENTS : MEDFIELD TREATMENT PLANT (contd.)
     ----------------------   -----------------------------------
                  (cases with aluminum salt addition)

 ----------------------------------------------------------------

  VARIABLE          MEAN      STD DEV      N     CORR  T-STAT     SIGNIF
 ----------------------------------------------------------------

  9.SB.FR         .92889 -1 .21262       18    .0624   .25000      .8058
 14.TSPFR         .98706     .84538 -2

  9.SB.FR                                 0
 15.VSSFR

  9.SB.FR         .11300     .34982       3   -.9061 -2.1417       .2781
 16.BODFR         .98233     .14434 -1

 10.SE.FR         .34636 -1 .63054       11    .7340  3.2424       .0101
 12.PFR           .87409     .61698 -1

 10.SE.FR         .34636 -1 .63054       11    .4231  1.4010       .1947
 13.TOCFR         .89627     .73808 -1

 10.SE.FR         .87800 -1 .63813       10   -.0949 -.26967       .7942
 14.TSPFR         .98690     .95272 -2

 10.SE.FR                                 0
 15.VSSFR

 10.SE.FR         .10500 -1 .71771        2 -1.0000
 16.BODFR         .98650     .17678 -1

 11.ZN.FR         .55300     .28416      20   -.0156 -.66300 -1  .9479
 12.PFR           .88215     .48778 -1

 11.ZN.FR         .55300     .28416      20    .3918  1.8066       .0876
 13.TOCFR         .88550     .93245 -1

 11.ZN.FR         .52589     .28601      18    .2472  1.0206       .3226
 14.TSPFR         .98789     .81881 -2

 11.ZN.FR                                 0
 15.VSSFR

 11.ZN.FR         .70367     .57726 -1    3    .2750   .28607      .8226
 16.BODFR         .98233     .14434 -1
```

```
   CORRELATION COEFFICIENTS : MEDFIELD TREATMENT PLANT (contd.)
   ------------------------------------------------------------
              (cases without aluminum salt addition)
----------------------------------------------------------------

  VARIABLE        MEAN      STD DEV       N     CORR   T-STAT     SIGNIF
-------------------------------------------------------------------------
   1.AG.FR       .84500    .57397 -1
  12.PFR         .31850    .28187         6  -.3889 -.84432       .4460

   1.AG.FR       .82820    .44735 -1
  13.TOCFR       .75240    .23579         5  -.9893 -11.759       .0013

   1.AG.FR       .85320    .60114 -1
  14.TSPFR       .98680    .89833 -2      5  -.9929 -14.478       .0007

   1.AG.FR
  15.VSSFR                                0

   1.AG.FR
  16.BODFR                                0

   2.AL.FR       .95686    .21894 -1
  12.PFR         .33964    .21479        14   .2061  .72963       .4796

   2.AL.FR       .95662    .22769 -1
  13.TOCFR       .80808    .16080        13  -.2632 -.90486       .3849

   2.AL.FR       .95929    .24158 -1
  14.TSPFR       .98750    .70356 -2     14  -.0014 -.47033 -2   .9963

   2.AL.FR
  15.VSSFR                                0

   2.AL.FR       .95350    .21213 -2
  16.BODFR       .98900    .14142 -2      2 -1.0000

   3.AS.FR      -.16200   1.1548
  12.PFR         .34840    .15074        10  -.1620 -.46436       .6548

   3.AS.FR      -.16200   1.1548
  13.TOCFR       .84770    .86754 -1     10  -.0507 -.14357       .8894

   3.AS.FR      -.22578   1.2060
  14.TSPFR       .98822    .62605 -2      9  -.0660 -.17499       .8660

   3.AS.FR
  15.VSSFR                                0
```

```
      CORRELATION COEFFICIENTS : MEDFIELD TREATMENT PLANT (contd.)
      ------------------------------------------------------------
                  (cases without aluminum salt addition)

  ------------------------------------------------------------------

   VARIABLE         MEAN      STD DEV        N      CORR  T-STAT     SIGNIF
  ------------------------------------------------------------------

   3.AS.FR        -1.8900    2.1185          2  1.0000
  16.BODFR         .98900    .14142 -2

   4.CD.FR         .86200    .91992 -1      11    .3987  1.3043      .2245
  12.PFR           .32236    .22209

   4.CD.FR         .85370    .92525 -1      10    .2850  .84083      .4249
  13.TOCFR         .78920    .17862

   4.CD.FR         .88390    .59506 -1      10    .2098  .60706      .5606
  14.TSPFR         .98610    .75196 -2

   4.CD.FR                                   0
  15.VSSFR

   4.CD.FR         .88700    .93338 -1       2  1.0000
  16.BODFR         .98900    .14142 -2

   5.CR.FR         .58271    .38996         14    .0551  .19129      .8515
  12.PFR           .33964    .21479

   5.CR.FR         .62277    .37472         13  -.3731 -1.3338       .2092
  13.TOCFR         .80808    .16080

   5.CR.FR         .56223    .39797         13    .1039  .34654      .7355
  14.TSPFR         .98685    .68659 -2

   5.CR.FR                                   0
  15.VSSFR

   5.CR.FR         .84850    .12940          2 -1.0000
  16.BODFR         .98900    .14142 -2

   6.CU.FR         .86664    .12233         14  -.1933 -.68257       .5078
  12.PFR           .33964    .21479

   6.CU.FR         .86208    .12608         13  -.1838 -.62032       .5477
  13.TOCFR         .80808    .16080

   6.CU.FR         .85977    .12448         13    .0049  .16344 -1  .9873
  14.TSPFR         .98685    .68659 -2
```

```
   CORRELATION COEFFICIENTS : MEDFIELD TREATMENT PLANT (contd.)
   ------------------------------------------------------------
              (cases without aluminum salt addition)

  -------------------------------------------------------------------

    VARIABLE          MEAN       STD DEV        N      CORR  T-STAT     SIGNIF
  -------------------------------------------------------------------

   6.CU.FR                                      0
  15.VSSFR

   6.CU.FR          .93700     .14142 -2       2  1.0000
  16.BODFR          .98900     .14142 -2

   7.HG.FR          .83679     .60695 -1      14  -.0487 -.16880       .8688
  12.PFR            .34993     .21955

   7.HG.FR          .84685     .49556 -1      13   .0505  .16755       .8700
  13.TOCFR          .79885     .16113

   7.HG.FR          .84447     .65618 -1      15   .6292  2.9190       .0120
  14.TSPFR          .98733     .68104 -2

   7.HG.FR                                      0
  15.VSSFR

   7.HG.FR          .82767     .35921 -1       3  -.9689 -3.9186       .1591
  16.BODFR          .98967     .15275 -2

   8.PB.FR          .80600     .19428         14   .1456  .50986       .6194
  12.PFR            .33964     .21479

   8.PB.FR          .81238     .20068         13   .0750  .24938       .8077
  13.TOCFR          .80808     .16080

   8.PB.FR          .79600     .19843         13   .0280  .92949 -1   .9276
  14.TSPFR          .98685     .68659 -2

   8.PB.FR                                      0
  15.VSSFR

   8.PB.FR          .80800     .19658          2  1.0000
  16.BODFR          .98900     .14142 -2

   9.SB.FR          .11143 -1  .41384         14   .3503  1.2956       .2195
  12.PFR            .33964     .21479

   9.SB.FR          .34154 -1  .42131         13   .3747  1.3404       .2071
  13.TOCFR          .80808     .16080
```

```
      CORRELATION COEFFICIENTS : MEDFIELD TREATMENT PLANT (contd.)
      ------------------------------------------------------------
                (cases without aluminum salt addition)

   ---------------------------------------------------------------------

     VARIABLE          MEAN       STD DEV        N     CORR  T-STAT    SIGNIF
   ---------------------------------------------------------------------

    9.SB.FR          .90000 -2 .43066          13   .1512  .50731     .6220
   14.TSPFR          .98685     .68659 -2

    9.SB.FR                                     0
   15.VSSFR

    9.SB.FR          .35900     0.              2 -0.
   16.BODFR          .98900     .14142 -2

   10.SE.FR          .22400     .17961          2 -1.0000
   12.PFR            .21650     .50700

   10.SE.FR          .22400     .17961          2 -1.0000
   13.TOCFR          .58100     .34224

   10.SE.FR          .22400     .17961          2 -1.0000
   14.TSPFR          .98150     .49497 -2

   10.SE.FR                                     0
   15.VSSFR

   10.SE.FR                                     0
   16.BODFR

   11.ZN.FR          .46400                     1
   12.PFR            .37700

   11.ZN.FR          .46400                     1
   13.TOCFR          .85600

   11.ZN.FR          .68050     .30618          2  1.0000
   14.TSPFR          .99250     .49497 -2

   11.ZN.FR                                     0
   15.VSSFR

   11.ZN.FR          .46400                     1
   16.BODFR          .98800
```